01 SOLID FUELS

Sources, winning, properties

08/00936 Abundance and modes of occurrence of mercury in some low-sulfur coals from China

Zheng, L. *et al. International Journal of Coal Geology*, 2008, 73, (1), 19–26.

Mercury (Hg) is one of the hazardous trace elements in coal. Mercury in coal is almost totally emitted into the atmosphere during coal combustion. Especially for utilities burning low-sulfur coals that do not require scrubbers, Hg reduction will be neglected. Hg abundances of 52 low-sulfur coal samples from different coalfields in six provinces of China were determined by a flow injection mercury system (FIMS). The results show that Hg abundances in selected low-sulfur coals range from 0.03 to 0.79 ppm, with an arithmetic mean of 0.24 ppm, which is higher than that of average Chinese coals (0.19 ppm). Correlation analysis and sequential extraction procedures are performed to study possible modes of occurrence of Hg in low-sulfur coals. Modes of occurrence of Hg are variable in low-sulfur coals, and the sulfide-bound and organic-bound Hg may be the dominant forms. In addition, the silicate-bound Hg may be the main form in some of these coals because of magmatic intrusion.

08/00937 Composition and mode of occurrence of mineral matter in some Colombian coals

Carmona, I. and Ward, C. R. *International Journal of Coal Geology*, 2008, 73, (1), 3–18.

The minerals in a range of Colombian coal samples, selected to represent the principal coal-mining regions, have been investigated using low-temperature ashing and quantitative X-ray diffraction techniques, and the results compared to information from chemical analysis and Mössbauer spectroscopy studies. Kaolinite, illite, interstratified illite–smectite and quartz are the dominant mineral matter components in almost all of the coal samples, with small but significant proportions of pyrite (up to around 15% of the mineral matter) being present in around half of the samples studied. Other minerals present in particular samples include chlorite, muscovite, paragonite, ankerite, dolomite, calcite and siderite, along with phosphate minerals apatite and goyazite. Jarosite and coquimbite are also noted in some of the pyrite-bearing coals, probably representing oxidation products of the pyrite developed with exposure or storage. Bassanite is present in the low-temperature ash of some coals, and in one sample occurs along with significant concentrations of hexahydrite, alunogen, tschermigite and paraluminite, all of which were probably derived from interaction of inorganic elements in the organic matter with organic sulfur during maceral oxidation. Quantitative analysis of the minerals in the low-temperature ash of the coal samples using Rietveld-based X-ray diffraction techniques provides results that are consistent, at least for the most abundant elements, with the chemical composition of the coal ash as determined by standard analysis procedures. The evaluation of mineral-rich concentrates by Mössbauer spectroscopy also provides results consistent with the XRD data, especially as regards pyrite and some of the sulphate components. Optical microscopy indicates that much of the pyrite, and in some cases also the carbonates, occurs as anhedral crystals, finely disseminated in the maceral components, as aggregates of crystals (including pyrite framboids), as fine-grained crystals replacing liptinite, and as fracture fillings. Some sub-angular to rounded quartz grains are also present, possibly of detrital origin, but most other minerals, including the clay minerals, occur mainly as aggregates of intimately admixed mineral and maceral constituents.

08/00938 Fractal characterization of adsorption-pores of coals from North China: an investigation on CH_4 adsorption capacity of coals

Yao, Y. *et al. International Journal of Coal Geology*, 2008, 73, (1), 27–42.

To better understand the characteristics of adsorption-pores (pore diameter <100 nm) and their influence on CH_4 adsorption capacity of coals, fractal analysis was conducted for 13 fresh coal samples (R_o from 0.79 to 4.24%) in North China. Isotherms of N_2 gas adsorption/desorption analyses indicate that coals have different adsorption characteristics at relative pressure of 0–0.5 and 0.5–1. On this basis, two fractal dimensions D_1 and D_2 (at relative pressure of 0–0.5 and 0.5–1, respectively) were obtained using the fractal Frenkel–Halsey–Hill (FHH) method, in which both proposed fractal exponents, '$(D-3)/3$' and '$(D-3)$' were investigated. The results show that the fractal exponent '$(D-3)$' provides more realistic results than fractal dimensions calculated from $(D-3)/3$. The two fractal dimensions, D_1 and D_2, have different correlations with CH_4 adsorption capacity of coals. The CH_4 adsorption capacity does not vary with increasing fractal dimension D_1 up to about 2.5, but thereafter increases with D_1. In contrast, the CH_4 adsorption capacity varies negatively with D_2 within the entire data range. Further investigation indicates that D_1 represents fractals from pore surface area generated by surface irregularity of coals, while D_2 characterizes fractals related to pore structures that are controlled by the composition (e.g. ash, moisture, carbon) and pore parameter (e.g. pore diameter, micropores content) of coals. Higher fractal dimension D_1 correlates to more irregular surfaces that provide more space for CH_4 adsorption. Higher fractal dimension D_2 represents higher heterogeneity of pore structure and higher liquid/gas surface tension that reduce CH_4 adsorption capacity. Therefore, more irregular coal surface and more homogeneous pore structure indicate higher CH_4 adsorption capacity of coals.

08/00939 Trace elements in the Goze Delchev coal deposit, Bulgaria

Eskenazy, G. M. and Stefanova, Y. S. *International Journal of Coal Geology*, 2007, 72, (3–4), 257–267.

The geochemistry of trace elements in the underground and open-pit mine of the Goze Delchev subbituminous coal deposit was studied. The coals in both mines are highly enriched in W, Ge and Be, and at less extent in As, Mn and Y as compared with the world-wide Clarkes for subbituminous coals. Ni and Ti are also enhanced in the underground coals, and Zr, Cr and Mo in the open-pit mine coals. Characteristic for the trace element contents in the deposit is a regular variation with depth. The following patterns were distinguished for profile I: (a) the element content decreases from the bottom to the top of the bed paralleling ash distribution (Fe, Co, As, Sb, V, Y, Mo, Cs, REE, Hf, Ta, Th, P and Au); (b) Ge and W are enriched in the near-bottom and near-top coals; (c) in the middle part of the bed the content of K and Rb is maximal, while that of U is slightly enriched; (d) Ba content decreases from the top to the bottom of the bed. In profile II, W and Be contents decrease from the bottom to the top. The near-bottom, and especially the near-roof samples of profile IV are highly enriched in Ge, while for W the highest is the content of the near-bottom sample. Ge, Be, As, Mn, Cl and Br are mainly organically associated. The organic affiliation is still strong for Co, B, Sr, Ba, Sb, U, Th, Mo, La, Ce, Sm, Tb and Yb in the underground coals, and Fe, Co, Na, W, Sr, Y and Ag in the coals from the open-pit mine. K, Rb, Ti, Zr, Hf and Ta are of dominant inorganic affinity. The chalcophile and siderophile elements correlate positively with Fe and each other and may be bound partly with pyrite or other sulfides and iron containing minerals. Compared statistically by the *t*-criteria, the elements Na, Li, Cu, Zn, Pb, Cr, Ni, Co, Mo, Fe and Be are of higher content in the open-pit mine. Tungsten is the only element of higher concentration in the underground mine. The contents of Ge, As, Sr, V, Mn, Y, Zr and P are not statistically different in both mines. It was supposed that there were multiple sources of the trace elements in the deposit. The sources of the highly enriched elements (W, Ge, Be, and As) most probably were the thermal waters in the source area. The contemporary mineral springs are of high content of these elements. Another source were the hosting Mesta volcanic rocks, which are enriched in Sb, Mo, Hf, U, Th, As, Li and Rb. Some of the volcanics were hydrothermally altered and enriched or depleted of many elements. Thus, the hydrothermal solutions were also suppliers of elements for the coals. It is obvious that the contents, distribution and paragenesis, of the trace elements in both Goze Delchev coals reflect the geochemical specialization of the source area, including rocks, paleo- and contemporary thermal waters.

08/00940 Underpinning-based simultaneous extraction of contiguous sections of a thick coal seam under weak and laminated parting

Mandal, P. K. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2008, 45, (1), 11–28.

Around 12.5 m-thick Zero seam of Chirimiri colliery underneath Bartunga hill of M/s South Eastern Coalfield Limited (SECL) was found in two sections; 3.5 m top and 6.0 m bottom section, with a highly laminated 3.0-m-thick parting between the two sections. The laminated parting, comprised of alternate layers of shale, carbonaceous shale, coal and mudstone, was found to be incompetent for safe and clean underground working of both sections. Both top and bottom sections were developed on superimposed pillars along the floor using roof bolts. Based on laboratory testing and investigations on simulated models, an idea of underpinning was conceived for simultaneous depillaring of both the contiguous sections. Taking advantage of presence of openings in the top section, the laminated parting and roof coal band of bottom section was reinforced simultaneously by a full-column grouted cable bolt of suitable length from the floor of the top section. Underpinning consolidated parting stability through reinforcement and provided additional thickness to the critical parting thickness as the roof coal band of the thick bottom section is stitched together with the parting. Maintaining superimposition of workings in the two sections, pillars of both the sections were extracted by splitting and slicing. Splits and slices of the bottom section did not experience roof instability problems due to the presence of the reinforced overlying roof coal band and parting by underpinning. The roof coal of the bottom section was blasted down on retreat. Consolidation of the multi-layered parting by underpinning did not allow separation and collapse of its mudstone/shale layers resulting in clean coal blasted from the roof. Underpinning-based simultaneous depillaring of the contiguous sections proved its technological feasibility and success through field trials.

08/00941 Upshot of strata movement during underground mining of a thick coal seam below hilly terrain

Singh, R. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2008, 45, (1), 29–46.

Underpinning-based simultaneous extraction was successfully used to extract more than 90% of thick and contiguous sections of a coal seam at Chirimiri mine, lying below a hill cap with a rapid change in depth of cover and is placed above the surrounding ground level. The last few panels of the mine encountered strata control problems during the depillaring. Underground instrumentation and observations showed that the last phase depillaring of the property near the free surface of the hill slope experienced shearing of overlying strata along two incompetent layers. Field investigations revealed that large amount of lateral movement due to the hilly nature of the overlying strata is the main source of the problem. A simple two-dimensional study on a simulated model also demonstrated the occurrence of the problem during working below an unconfined rock mass of hilly nature. Different evidences were collected from the site to identify the main horizons and the direction of lateral movement and, accordingly, two different strata management plans, one for each section, were successfully executed to overcome the encountered strata control problems. Field investigations in the rest of the panels of the site showed favourable impact of the adopted strata management plan.

Preparation

08/00942 Adapting palynological preparation methods in subbituminous and bituminous coals from Colombia to improve palynofacies and hydrocarbon source rock evaluations

Blandon, A. *et al. International Journal of Coal Geology*, 2008, 73, (2), 99–114.

Apart from their potential as fossil fuel, bituminous and subbituminous coals in Colombia may prove to be potential source rocks for the generation of hydrocarbons. The assessment of such properties requires the combination of petrographic and palynofacies studies. The latter correspond to the microscopic investigation in transmitted white and reflected UV lights of sedimentary organic matter insoluble in organic and inorganic solvents. To date, mineral acid and Schulze methods have failed to produce good samples of palynofacies constituents from Cenozoic coals in Colombia, so that the latter method had to be modified. The main modifications consist in adapting the $KClO_3$ to HNO_3 ratio in the Schulze mixture and introducing two extra phases of oxidation with NaOH and NH_4OH, which permit the washing off of humic substances. This method yields the full spectrum of palynofacies constituents, which are not destroyed or damaged by the alkali treatment. Neither is their fluorescence colour affected by the initial acid treatment. On the contrary, the particle fluorescence intensity tends to increase because of the dissolution of humic acids, making their identification easier. The achievements of the modified method are threefold: (1) it permits the correlation between macerals in petrographic polished sections and their equivalent in palynofacies slides, making the two methods complementary; (2) palynofacies provides a better identification of sporomorphs than petrography, resulting in better paleoenvironmental interpretations; (3) palynofacies tend to give a more precise quantitative evaluation of the liptinitic constituents, and consequently, of the coal hydrocarbon generation potential.

08/00943 Leaching experiments to study the release of trace elements from mineral separates from Chinese coals

Yue, M. and Zhao, F. *International Journal of Coal Geology*, 2008, 73, (1), 43–51.

Leaching experiments were carried out for two samples of mineral separates from Chinese coals for the purpose to simulate the release of trace elements in acid mine drainage. The leaching solution has a ferric ion concentration of 10^{-3} M, pH ≈ 2. The experiments were carried out at room temperature. The grain size of the mineral separates is 75–130 μm. The behaviour of the release of eight trace elements (Co, Ni, Zn, Cd, Al, Cr, As, and Pb) were measured during the period of 312h. The results from four leaching tests using two samples with two solid-to-liquid ratios show that the concentrations of Co, Ni, Zn, and Cd continuously increased during the leaching period and they were correlated with the sulfate content in the same leachate. This indicates that the elements were released during the oxidation and dissolution of pyrite. The elements were easily dissolved in the leaching solution. On the other hand, the concentrations of Al, Cr, As, and Pb in the leachates varied considerably under same leaching conditions and were sensitive to the condition of the leachate during the leaching process. The release of these four elements was affected by the pH of the leachate and by absorption and co-precipitation. They are less likely to migrate. Therefore, the release and migration of the eight elements in acid coal-mine drainage are controlled mainly by three factors, the oxidation of pyrite, the pH of the leachate, and mineralogy of country rocks.

08/00944 Prediction of coal grindability based on petrography, proximate and ultimate analysis using multiple regression and artificial neural network models

Chelgani, S. *et al. Fuel Processing Technology*, 2008, 89, (1), 13–20.

The effects of proximate and ultimate analysis, maceral content, and coal rank (R_{max}) for a wide range of Kentucky coal samples from calorific value of 4320–14,960 (BTU/lb) (10.05 to 34.80 MJ/kg) on Hardgrove Grindability Index (HGI) have been investigated by multivariable regression and artificial neural network methods (ANN). The stepwise least square mathematical method shows that the relationship between (a) Moisture, ash, volatile matter, and total sulfur; (b) ln (total sulfur), hydrogen, ash, ln ((oxygen + nitrogen)/carbon) and moisture; (c) ln (exinite), semifusinite, micrinite, macrinite, resinite, and R_{max} input sets with HGI in linear condition can achieve the correlation coefficients (R_2) of 0.77, 0.75, and 0.81, respectively. The ANN, which adequately recognized the characteristics of the coal samples, can predict HGI with correlation coefficients of 0.89, 0.89 and 0.95 respectively in testing process. It was determined that ln (exinite), semifusinite, micrinite, macrinite, resinite, and R_{max} can be used as the best predictor for the estimation of HGI on multivariable regression ($R_2 = 0.81$) and also artificial neural network methods ($R_2 = 0.95$). The ANN based prediction method, as used in this paper, can be further employed as a reliable and accurate method, in the hardgrove grindability index prediction.

08/00945 Treatments of low rank coals for improved power generation and reduction in Greenhouse gas emissions

Domazetis, G. *et al. Fuel Processing Technology*, 2008, 89, (1), 68–76.

Reduction in ash constituents by water washing, and also at specific pH values, was systematically studied for three low-rank coals. Acid treatment removed inorganic constituents if accompanied by efficient water washing; at elevated temperatures this can also reduce moisture. The ash components are present in the coal matrix and also as numerous aluminosilicates particles containing K, Na, Mg, Fe and Ca; acid treatment reduced the ash constituents to mainly quartz and clay particles. The ash chemistry of treated and untreated coals was studied over the temperature range 800–1400 °C. The ash from treated coals consisted mostly of α-quartz, and when heated at 800–1500 °C, was transformed into mainly amorphous silica and cristobalite, and melted at 1300–1500 °C. Ash from untreated coals melted at or below 1100 °C. The impact of low rank coals with lower moisture, and also coals with lower ash and moisture, was assessed for power generation using the GateCycle^{TM} package. The results show: (i) moisture reduction lowers CO_2/MWh by a small amount but often increases fouling, and (ii) reduction in ash and moisture would eliminate ash fouling and significantly reduce the CO_2/MWh compared with current power plant.

Transport, storage

08/00946 Coal beneficiation of Candiota mine by dry jigging

Sampaio, C. H. *et al. Fuel Processing Technology*, 2008, 89, (2), 198–202.

The objective of this work is to test dry jigging, operated with air, to eliminate pyrite nodules and liberated clays from Candiota coal. Candiota mine is the biggest Brazilian Coal deposit, which is beneficiated for fueling a thermoelectric plant. This coal presents a high degree of liberated pyrite in a wide range of densities. Hence, gravity separation of pyrite appears apparently obvious. However, any wet treatment results difficult due to the high porosity of the material as a consequence of its low rank. For that reason, dry jigging was proved instead with encouraging results. Samples from the upper layer of the seam, which had around 1.8% sulfur and about 51% ash, appeared after jigging with about 0.7% sulfur and near 47% ash. After these results, pilot jigs are planned to install at the plant.

Economics, business, marketing, policy

08/00947 Clean combustion of solid fuels

Wang, J. and Anthony, E. J. *Applied Energy*, 2008, 85, (2–3), 73–79.

A chemical-looping process is proposed for the clean combustion of solid fuels for electric power or heat generation. The process is based on coal gasification with CO_2 to produce CO. The CO then reduces $CaSO_4$, which is used as an oxygen carrier, in a separate reactor to give CaS and CO_2. A portion of the CO_2 is recycled for the gasification stage and the rest can be sent for sequestration. The CaS is sent to another reactor for oxidation with air and to generate heat or power. The overall thermal effect is the same as direct combustion, but separation of CO_2 and other pollutants, such as sulfur, is achieved. In comparison with conventional chemical-looping combustion of natural gas, much less water is present in the CO_2 product, and hence the loss of heat energy and corrosion of the fuel–reactor system can be reduced.

08/00948 Hydrocarbon potential of Pennsylvanian coal in Bohai Gulf Basin, Eastern China, as revealed by hydrous pyrolysis

Li, R. *et al. International Journal of Coal Geology*, 2008, 73, (1), 88–97.

A hydrous-pyrolysis experiment was performed using Pennsylvanian brown coal with a vitrinite reflectance (VR_0) of 0.56% from a coal mine at the southwest corner of the Bohai Gulf Basin, eastern China, to evaluate the hydrocarbon potential of the coal. The coal sample is vitrinite-rich (74.5%) and inertinite-poor (16.7%) with liptinite content of 8.8%. Much of the vitrinite in the sample consists of hydrogen-rich vitrinite (collodetrinite). Hydrous pyrolysis was performed at 200, 230, 260, 290, 320, and 350 °C for 72 h separately. Yields of both total liquid pyrolysates and expelled oil increased with temperature before reaching their maximum production of 17.27 kg/t coal and 14.57 kg/t coal at the same temperature of 320 °C ($VR_0 = 1.18\%$), and decreased afterwards. Gaseous products increased sharply at 320 °C and tended to increase even at the highest experimental temperature (350 °C; $VR_0 = 1.53\%$). Results show that the coal has not only a certain oil-generation potential but also a large capacity for gas production and a high expulsion efficiency. Oil potential of the coal is attributed to its depositional environment, which was transitional from shallow marine to coastal plain or swamp during middle to Late Pennsylvanian. The coal was protected from oxidation under water after deposition. Experimental results indicate that this Pennsylvanian coal could have contributed to oil/gas accumulation in the Bohai Gulf Basin.

08/00949 Organic compounds in produced waters from coalbed natural gas wells in the Powder River Basin, Wyoming, USA

Orem, W. H. *et al. Applied Geochemistry*, 2008, 22, (10), 2257–2272.

The organic composition of produced water samples from coalbed natural gas (CBNG) wells in the Powder River Basin, WY, sampled in 2001 and 2002 are reported as part of a larger study of the potential health and environmental effects of organic compounds derived from coal. The quality of CBNG produced waters is a potential environmental concern and disposal problem for CBNG producers, and no previous studies of organic compounds in CBNG produced water have been published. Organic compounds identified in the produced water samples included: phenols, biphenyls, N-, O-, and S-containing heterocyclic compounds, polycyclic aromatic hydrocarbons (PAHs), aromatic amines, various non-aromatic compounds, and phthalates. Many of the identified organic compounds (phenols, heterocyclic compounds, PAHs) are probably coal-derived. PAHs represented the group of organic compounds most commonly observed. Concentrations of total PAHs ranged up to 23 μg/L. Concentrations of individual compounds ranged from about 18 to <0.01 μg/L. Temporal variability of organic compound concentrations was documented, as two wells with relatively high organic compound contents in produced water in 2001 had much lower concentrations in 2002. In many areas, including the PRB, coal strata provide aquifers for drinking water wells. Organic compounds observed in produced water are also likely present in drinking water supplied from wells in the coal. Some of the organic compounds identified in the produced water samples are potentially toxic, but at the levels measured in these samples are unlikely to have acute health effects. The human health effects of low-level, chronic exposure to coal-derived organic compounds in drinking water are currently unknown. Continuing studies will evaluate possible toxic effects from low level, chronic exposure to coal-derived organic compounds in drinking water supplies.

08/00950 The effects of resource depletion on coal mining productivity

Rodríguez, X. A. and Arias, C. *Energy Economics*, 2008, 30, (2), 397–408.

The Solow Residual has a direct interpretation as a measure of technical change under perfect competition and constant returns to scale. When these conditions do not hold, the residual has to be appropriately adjusted in order to be considered a correct measure of technical change. The authors argue that in extractive industries the Solow Residual is also affected by the continuous depletion of a non-renewable resource. Therefore, a new decomposition of the Solow Residual is provided for extractive industries in which the level of reserves is likely to affect extraction costs. The empirical results illustrate the role played by the depletion of reserves in the measurement of productivity of coal mining in Spain.

08/00951 The long-term life cycle private and external costs of high coal usage in the US

Bergerson, J. and Lave, L. *Energy Policy*, 2007, 35, (12), 6225–6234.

Using four times as much coal in 2050 for electricity production need not degrade air quality or increase greenhouse gas emissions. Current SO_x and NO_x emissions from the power sector could be reduced from 12 to less than 1 and from 5 to 2 million tons annually, respectively, using advanced technology. While direct CO_2 emissions from new power plants could be reduced by over 87%, life cycle emissions could increase by over 25% due to the additional coal that is required to be mined and transported to compensate for the energy penalty of the carbon capture and storage technology. Strict environmental controls push capital costs of pulverized coal (PC) and integrated coal gasification combined cycle (IGCC) plants to $1500–1700/kW and $1600–2000/kW, respectively. Adding carbon capture and storage (CCS) increases costs to $2400–2700/kW and $2100–3000/kW (2005 dollars), respectively. Adding CCS reduces the 40–43% efficiency of the ultra-supercritical PC plant to 31–34%; adding CCS reduces the 32–38% efficiency of the GE IGCC plant to 27–33%. For IGCC, PC, and natural gas combined cycle plants, the carbon dioxide tax would have to be $53, $74, and $61, respectively, to make electricity from a plant with CCS cheaper. Capturing and storing 90% of the CO_2 emissions increases life cycle costs from 5.4 to 11.6 cents/kWh. This analysis shows that 90% CCS removal efficiency, although being a large improvement over current electricity generation emissions, results in life cycle emissions that are large enough that additional effort is required to achieve significant economy-wide reductions in the US for this large increase in electricity generation using either coal or natural gas.

Derived solid fuels

08/00952 Boiling heat transfer enhancement with carbon nanotubes for refrigerants used in building air-conditioning

Park, K.-J. and Jung, D. *Energy and Buildings*, 2007, 39, (9), 1061–1064.

In this study, the effect of carbon nanotubes (CNTs) on nucleate boiling heat transfer is investigated. Two halocarbon refrigerants of R123 and R134a for building chillers were used as working fluids and 1.0 vol.% of CNTs was added to them to examine the heat transfer enhancement with CNTs. The experimental apparatus was composed of a stainless steel vessel and a 152.0 mm long plain horizontal tube of 19.0 mm outside diameter heated by a cartridge heater. All data were obtained at the pool temperature of 7 °C in the heat flux range of 10–80 $kW\,m^{-2}$. Test results showed that CNTs increase nucleate boiling heat transfer coefficients for these refrigerants. Especially, large enhancement up to 36.6% was observed at low heat fluxes of less than 30 $kW\,m^{-2}$. With increasing heat flux, however, the enhancement was suppressed due to vigorous bubble generation. Fouling on the heat transfer surface was not observed during the course of this study. Optimum dispersion of CNTs should be examined for their commercial application to enhance nucleate boiling heat transfer in building air-conditioning applications.

08/00953 Combustion of a coal char particle in a stream of dry gas

Higuera, F. J. *Combustion and Flame*, 2008, 152, (1–2), 230–244.

The burning rate, surface temperature, drag, and extinction conditions of a single char particle moving in a gas are computed numerically. The effects of the size and velocity of the particle and of the temperature and composition of the gas are examined in the framework of a simple model that includes O_2 and CO_2 heterogeneous reactions and, in some cases, a diffusion-controlled CO oxidation flame in the gas around the particle. In agreement with known results, the burning rate is found to increase with the velocity of the particle when the Reynolds number of the gas flow ceases to be small. The temperature of the particle increases with the temperature and oxygen mass fraction of the gas and is little affected by the size and velocity of the particle, except in the vicinity of extinction. The drag coefficient is a decreasing function of the particle size and velocity in the range of Reynolds numbers that has been analysed. The presence of CO_2 in the gas may have an important effect on the gasification of small particles.

08/00954 Open loop response to changes of coke-precursors during fluidised-bed catalytic cracking

León-Becerril, E. and Maya-Yescas, R. *Fuel*, 2007, 86, (9), 1282–1289.

Management of coke is very important during industrial operation of fluidized-bed catalytic cracking units; this coke can be classified into two categories. The first one is 'additive coke', which comes as precursors in feedstock from up-stream processes such as vacuum distillation; this coke is deposited on the catalyst surface independently from kinetic rates, catalyst/oil ratio or kind of catalyst. The second one is coke produced in cracking reactions, which depends on catalyst activity and catalyst/oil ratio. Both kinds of coke, additive and product, are deposited on catalyst surface and busted during regeneration. Due to normal changes in feedstock composition, the amount of coke precursors might oscillate during industrial operation. This situation would be seen as a change in the effective yield to coke in the riser and, consequently, a variation in the heat production rate during regeneration reactions, which could modify regenerator operating temperature; therefore several control studies are focused to the rejection of this disturbance. In this work, a mathematical model of industrial FCC units is used to simulate open-loop responses to different changes of coke precursors, it is found that FCC units are able to manage these disturbances without control actions, up to certain limits around the operating region; therefore control studies should consider this self-stabilization ability prior to propose closed-loop operating policies.

08/00955 Phenolic resin binder for the production of metallurgical quality briquettes from coke breeze: Part I

Benk, A. *et al. Fuel Processing Technology*, 2008, 89, (1), 28–37.

Phenol based novalac, resol and the blend of both resins were used as binders in briquette production from coke breeze. The effects of the amount of catalyst on the tensile strength of the cured briquette were studied. The results obtained have indicated that the highest tensile strength could not be attained unless the blend of novalac and resol was used as binder. The most suitable blend was the binder prepared from the hydrochloric acid catalysed novalac of $F/P = 0.5$ and the $N/P = 0.3$ catalysed resol of $F/P = 2.0$. When this blend was used as a binder the tensile strength of the cured briquettes did not drop even if they were carbonized at 470 °C and 570 °C. Their strengths at these carbonization temperatures were 67 MPa and 72 MPa respectively, and the rise in the temperature resulted in some increase in their strength. These results show the fact that as the formed coke briquettes descends from the top of the blast furnace, the rise in temperature will not deteriorate their strength; it will probably improve their properties. Therefore, only curing at 200 °C for 2 h will be sufficient for the briquettes to be used as substitute for metallurgical coke in the blast furnace.

08/00956 Phenolic resin binder for the production of metallurgical quality briquettes from coke breeze: Part II the effect of the type of the basic catalyst used in the resol production on the tensile strength of the formed coke briquettes

Benk, A. *et al. Fuel Processing Technology*, 2008, 89, (1), 38–46.

In order to develop a new and cost effective formed coke production process which does not require higher temperature carbonization stage, coke breeze was briquetted with resol binders and the change in the tensile strength of the briquettes with the amount and the type of the alkaline metal hydroxides, alkaline earth metal oxides, their carbonates and amine catalysts were studied. It was recognized that carbonates of alkaline or alkaline earth metals have a modifying effect on the properties of resol binders which results in briquettes of higher tensile strength than the resol produced with hydroxide or oxides of these metals. The average tensile strength of the briquettes was found to be much higher with the sodium carbonates catalysed resol used as binder comparing with sodium hydroxide catalysed resoles. The former was 45.40 MPa while the latter was 33.72 MPa. Although triethanolamine catalysed resol, resulted in the briquettes of the highest tensile strength (53.43 MPa), among the catalyst studied in this work, due to flammability caused by triethanolamine, it was found unsuitable for this purpose.

08/00957 Raman characterization of single-walled carbon nanotubes produced by the catalytic pyrolysis of methane

Seifi, M. *et al. Carbon*, 2007, 45, (9), 1871–1879.

Bundles of single-wall carbon nanotubes (SWCNT) were synthesized using a chemical vapour deposition technique. This basic process was optimized over a wide range of process parameters. For the optimal results, ethane was decomposed at 950 °C over a catalyst material consisting of 2% by wt Fe chemically deposited on an MgO support. The samples were characterized using scanning electron microscopy and transmission electron microscopy to show the presence of nanotubes and also to measure their diameters and the size of amorphous carbon deposits. Raman scattering was also used to probe the electronic properties and hence derive the distribution of diameters of the SWCNT. Samples were measured in both the radial breathing mode and tangential mode ranges using three different laser lines. For comparison purposes, similar data have been reported for a standard commercial SWCNT material (HiPCO). From the data, it can be concluded that the tubes in the sample are significantly different to those in the HiPCO sample. In particular, the authors conclude that samples produced by the method contain a much narrower distribution of tube diameters than does the commercial sample.

02 LIQUID FUELS

Sources, properties, recovery

08/00958 Bulk mineralogical characterisation of oilfield reservoir rocks and sandstones using Diffuse Reflectance Infrared Fourier Transform Spectroscopy and Partial Least Squares analysis

Breen, C. *et al. Journal of Petroleum Science and Engineering*, 2008, 60, (1), 1–17.

The feasibility of applying partial least squares (PLS) to the diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) spectra of mineral mixtures, quarry sandstones and oilfield reservoir rocks has been investigated and shown considerable potential for accurate and precise mineralogical analysis. Rapid spectrum acquisition and data processing together with small sample size requirements are key advantages of the PLS–DRIFTS method. A PLS model was created from the DRIFTS spectra of mixtures of seven mineral standards chosen to represent the most frequently encountered minerals in sandstone-type rocks; quartz, dolomite, montmorillonite, illite, kaolinite, chlorite and albite. The PLS–DRIFTS model was able to quantify the mineral components of independent mixtures with an absolute error of 1 wt.% for all the minerals (concentration range 0–30 wt.%) with the exception of quartz which exhibited an absolute error of 3 wt.% (concentration range 50–90 wt.%). The results provided by applying this PLS–DRIFTS model to several sandstone-type quarry rocks and a suite of oilfield reservoir rocks were considerably better than anticipated even though the model did not describe all the mineral components present in the samples nor the entire variance of constituent mineral components (e.g. crystallinity). The model was not able to differentiate between montmorillonite and illite probably due to the similarity of the DRIFTS spectra of these minerals, but it was able to quantify the combined (montmorillonite + illite) concentrations to within 1 wt.%. The model over-predicted the concentration of albite in the quarry rocks due to the presence of K-feldspar, which has a similar DRIFTS spectrum and was not included in the model. However, the model accurately predicted the total (albite and K-feldspar) concentration to within 4 wt.%. A separate PLS–DRIFTS model constructed using the DRIFTS spectra of the oilfield reservoir rocks showed that the carbonate components, calcite and dolomite could be differentiated and quantified to within 5.0 and 3.6 wt.%, respectively. This feasibility study confirmed the strong potential of combining DRIFTS with a multivariate statistical approach such as PLS and it is clear that more sophisticated models, that incorporates and describes a higher percentage of the variance in unknowns, would further improve the predictions.

08/00959 Estimation of activation energies during hydrodesulfurization of middle distillates

Reséndiz, E. *et al. Fuel*, 2007, 86, (9), 1247–1253.

Hydrodesulfurization (HDS) of different petroleum distillates was carried out in a batch reactor using commercial CoMo catalyst and reaction conditions similar to industrial practice. Various experiments (agitation, particle size and amount of catalyst tests) were conducted with different hydrocarbon feeds to assure the operation under kinetic regime. Reaction orders and activation energies for each feed were determined by two approaches (linear and non-linear regressions). Both kinetic parameters (n and E_A) were found to follow a direct relationship with sulfur content in the feed. Reaction orders ranged between 1.96 and 3.36 and activation energies from 21.49 to 41.96 kcal/mol, which were within the range of those reported in the literature. High values of reaction order were attributed to contributions of HDS reaction of each individual compound exhibiting very different reaction rate constants.

08/00960 Evolution of hydrocarbon migration style in a fractured reservoir deduced from fluid inclusion data, Clair Field, west of Shetland, UK

Baron, M. *et al. Marine and Petroleum Geology*, 2008, 25, (2), 153–172.

A petrographic and fluid inclusion microthermometric study was performed on sandstones from the Devonian-Carboniferous reservoir rocks of the Clair Field, west of Shetland. Fluid inclusion petrographic and microthermometric observations were collected from quartz, K-feldspar and calcite cements and veins. Vein and cement minerals host both aqueous and hydrocarbon two-phase (liquid and vapour-filled) fluid inclusions indicating that cementation occurred during oil charging. The location of hydrocarbon fluid inclusions in the paragenetic sequence of the reservoir rocks indicates that hydrocarbon migration during early-stage diagenesis occurred via intergranular pores as well as fractures, whereas towards the later stages of diagenesis, as porosities were occluded, hydrocarbon migration was predominantly fracture controlled. The microthermometric characteristics of primary and secondary aqueous fluid inclusions in association with hydrocarbon fluid inclusions indicates that cementation and veining during oil charging occurred at temperatures up to 180 °C. Salinity values are variable (0–10.9 wt% NaCl eq.) indicating that fluid mixing occurred during veining and cementation. Basin modelling and vitrinite reflectance data indicate that temperatures of up to 180 °C could not have been attained through burial alone. The high temperatures attained during late-stage diagenesis are interpreted to be caused by high temperature, short-lived fluids circulating within the Devonian-Carboniferous reservoir rocks in association with late Cretaceous and Paleocene magmatism. These high temperature fluid flow events were not recorded in the vitrinite reflectance data because of their short duration.

08/00961 Generation and expulsion of petroleum from coal macerals visualized *in-situ* during DAC pyrolysis

Mo, H.-J. *et al. International Journal of Coal Geology*, 2008, 73, (2), 167–184.

Liptinites, vitrinites and fusinites separated from coals of different maturity were characterized using SEM, NMR, IR, XRD and DAC-fluorescence. Their oil and gas generative potentials during thermal cracking have been evaluated by visual observations *in-situ* in a diamond anvil cell during semi-open and closed system pyrolysis. It has been shown that liptinite generated large amounts of visible oil-like liquid along with some gas, while fusinites generated no visible liquid and gas. The liquid (oil) from liptinite appears light in colour and less viscous. In contrast, some non-perhydrous vitrinite unexpectedly generated large amounts of visible liquid, although the liquid is darker and thicker than that from liptinite, indicating that the oil potential of vitrinites is not limited to its perhydrous nature. The visual observations of oil generative potential are generally consistent with those implied from IR, XRD, NMR, and fluorescence. The peak temperatures (T_{peak}) of maximum rate of liquid petroleum generation for vitrinite (465–540 °C) are generally higher than those for liptinites (453–475 °C); both of which are within the range of Rock-Eval T_{peak} for most organic matter. The visual oil generation potential is essentially similar in closed and semi-open systems, whereas the gas generation appears more noticeable in a closed system. Since semi-open experiments are much easier to perform, the DAC pyrolysis may be routinely conducted as a semi-open system if only oil generation is considered. In addition, the DAC pyrolysis revealed that oil retention capacity of liptinite is lower than vitrinite, thus the expulsion of oil from liptinite may not be a rate limiting step for primary migration. In contrast, the expulsion of oil from vitrinite is relatively inefficient because of the lower fluidity of the liquid and probably the high retention capability of the vitrinite molecular network.

08/00962 Liquid fuel combustion within silicon-carbide coated carbon foam

Vijaykant, S. and Agrawal, A. K. *Experimental Thermal and Fluid Science*, 2007, 32, (1), 117–125.

Combustion of kerosene inside porous inert medium (PIM) has been investigated with the goal of reducing the emissions of nitric oxides (NO_x), carbon monoxide (CO) and soot. Silicon-carbide (SiC) coated carbon foam is used as PIM to attain high structural strength. The two-zone porous burner design consists of preheat and combustion sections. Different PIM configurations were tested by stacking together square porous pieces of 2.5 cm thickness. Two types of fuel injectors are considered: (i) in the air-assist injector, approximately 5% of the combustion air is used for atomization and the remaining air enters as the primary co-flow around the injector, and (ii) in the swirling-air injector, all of the combustion air enters the injector to create a swirling flow around the fuel jet to enhance atomization and fuel–air premixing. The distance between the injector and PIM inlet is a key operational parameter, which was varied in experiments with both injectors over a range of equivalence ratios and heat release rates. The NO_x and CO emissions were measured to optimize the PIM configuration with minimum emissions. Results show stable combustion over a wide operating range. Three combustor operational regimes are identified depending upon the injector location.

08/00963 Magmatism and petroleum exploration in the Brazilian Paleozoic basins

Filho, A. T. *et al. Marine and Petroleum Geology*, 2008, 25, (2), 143–151.

Petroleum exploration in the Paleozoic sedimentary basins of Brazil has proven very challenging for explorationists. Except for the Solimões Basin, in which transcurrent tectonism formed prospective structural highs, Brazilian Paleozoic basins lack intense structural deformation, and hence the detection and prospecting of place is often difficult. Magmatic intrusive and associated rocks in all these basins have traditionally been considered heat sources and hydrocarbon traps. The role of tholeiitic basic dikes in the generation, migration and accumulation of petroleum in the Anhembi oil occurrence (São Paulo State) is discussed herein. It follows that similar geological settings in other Paleozoic basins can be regarded as promising sites for oil accumulation that warrant investigation via modern geological and geophysical methods.

08/00964 Modification of Hβ zeolite by fluorine and its influence on olefin alkylation thiophenic sulfur in gasoline

Zhang, Z. *et al. Fuel Processing Technology*, 2008, 89, (1), 103–110.

By modifying the Hβ zeolite with proper amount HF, the catalytic performance of fluorinated Hβ was obviously improved for the olefin alkylation thiophenic sulfur process. Particularly, the acid sites of the fluorinated Hβ catalysts were increased, especially its distribution of medium and stronger Lewis and Brönsted acid sites was optimized, and its thiophene alkylation activity and stability are thus promoted as well as its coking behaviour is suppressed during OATS process.

08/00965 Origin of oils in the Velebit oil–gas field, SE Pannonian Basin, Serbia – source rocks characterization based on biological marker distributions

Šolević, T. *et al. Organic Geochemistry*, 2008, 39, (1), 118–134.

Twenty five crude oil samples from Velebit oil–gas field (SE Pannonian Basin, Serbia) were investigated in order to define the depositional environment, lithology, thermal maturity and depth of burial of the corresponding source rocks. Saturated biomarkers (*n*-alkanes, isoprenoids, steranes and triterpanes) were determined using gas chromatography (GC) and gas chromatography–mass spectrometry–mass spectrometry (GC–MS–MS). Source and maturity parameters were calculated from the distribution and abundance of biomarker compounds and principal component analysis (PCA) was used to interpret their relationships. The Velebit crude oils were generated from siliciclastic source rocks containing a mixture of terrestrial and marine organic matter that was deposited under a predominantly reducing environment, probably in the distal marine portion of a delta. Maturation parameters indicated significant thermal maturity corresponding to peak oil generation. Age-diagnostic biomarker ratios suggest that the source of Velebit oils may be Upper Cretaceous, older than most oils in the Pannonian Basin, which are generated from Tertiary sources. These source rocks are thought to be at a present-day depth of approximately 3000 m, within or in close proximity to, the oil field.

08/00966 Pliocene paleoenvironment evolution as interpreted from 3D-seismic data in the southern North Sea, Dutch offshore sector

Kuhlmann, G. and Wong, T. E. *Marine and Petroleum Geology*, 2008, 25, (2), 173–189.

A high-resolution 3D-seismic survey from the Dutch offshore sector has been interpreted and subsequently correlated with existing regional seismo-stratigraphic concepts derived from conventional 2D-seismic data sets. The interpreted 13 seismic units have been related to a newly established chrono-stratigraphic framework resulting in up-dated age control for the seismic units. The generation of amplitude maps, time slices and isopach maps from the 3D-seismic data enabled detailed spatial and temporal reconstruction regarding the paleoenvironmental and climatological development. The lowermost seismic units S1–S4 comprise condensed Middle Miocene to Piacencian sediments, deposited under warm open marine conditions. These sediments show a uniform seismic facies of low-amplitude reflectors. The boundary of seismic unit S4–S5 (around 2.6 Ma) delineates a shift towards generally colder climate conditions that are connected to the onset of Northern Hemisphere Glaciation. Seismic unit S5 includes alternations of warmer and colder periods. During warmer periods, bottom currents generated elongated structures (2.5–4 km long, 300–500 m wide) on the horizon display. These layers show as well shallow gas accumulations with a more regional extent and are related to coarser-grained sediments sealed by clayey sediments of the cold phases. A homogenous seismic facies is characteristic for the colder periods. Within seismic units S6 and S7, internal fore set structures display the regressional trend related to the cooling of this interval. Seismic units S8–S11 display a pattern of unoriented lineaments which was probably caused by icebergs drifting into the North Sea and souring the sea floor. This finding is in accordance with the shallow marine, arctic conditions of this interval. Within these units a bright spot of 3 by 7 km in size, is interpreted to result from shallow gas accumulation related to a grounded iceberg. This feature represents another, more local area of gas accumulation that is closely related to iceberg activity within the study area. The uppermost seismic units S12 and S13 belong to a fluvial, paralic paleo-environment, that is characterized by aggradational seismic reflectors. Pleistocene glacial valleys were recognized in the upper 200 m below sea floor.

08/00967 Source rock characterization and petroleum systems of Eocene Tyee basin, southern Oregon Coast Range, USA

Ryu, I.-C. *Organic Geochemistry*, 2008, 39, (1), 75–90.

The hydrocarbon source rock potential of the Eocene units in the southern Oregon Coast Range was evaluated using Rock-Eval pyrolysis. Most Eocene units in southern Oregon Coast Range are thermally immature and contain lean, gas prone Type III kerogen. However, some beds (coals) are sufficiently organic rich to be sources of biogenic and thermogenic methane discovered in numerous seeps. The overall hydrocarbon source rock potential of the southern Oregon Coast Range is moderately low; however, requirements for commercial accumulations of hydrocarbon probably exist locally within and adjacent areas. Two speculative petroleum systems are proposed. The first includes the southern part of the Oregon Coast Range near the border with the Mesozoic Klamath Mountains and is related to a proposed subduction zone maturation mechanism along thrust faults. The second occurs near the eastern border of the range where maturation is related to heating by sills and migration of hydrothermal fluids associated with mid-Tertiary volcanism in the western cascade arc.

Transport, refining, quality, storage

08/00968 A comparative study on the effect of promoter content of hydrodesulfurization catalysts at different evaluation scales

Leyva, C. *et al. Fuel*, 2007, 86, (9), 1232–1239.

CoMo and NiMo supported Al_2O_3 catalysts have been investigated for hydrotreating of model molecule as well as industrial feedstock. Activity studies were carried out for thiophene and SRGO hydrodesulfurization (HDS) in an atmospheric pressure and batch reactor respectively. These activities on sulfided catalysts were evaluated as a function of promoter content [M/(+ Mo) = 0.30, 0.34, 0.39; M = Co or Ni] using fixed (ca. 8 wt.%) molybdenum content. The promoted catalysts were characterized by textural properties, XRD, and temperature programmed reduction (TPR). TPR spectra of the Co and Ni promoter catalysts showed that Ni promotes the easy reduction of Mo species compared with Co. With the variation of promoter content NiMo catalyst was found to be superior to CoMo catalyst for gas oil HDS, while at low-promoter content the opposite trend was observed for HDS of thiophene. The behaviour was attributed to the several reaction mechanisms involved for gas oil HDS. A nice relationship was obtained for hydrodesulfurized gas oil refractive index and aromatic content, which corresponds to the Ni hydrogenation property.

08/00969 Characterization and distribution of petroleum hydrocarbons and heavy metals in groundwater from three Italian tank farms

Riccardi, C. *et al. Science of the Total Environment*, 2008, 393, (1), 50–63.

The present paper highlights the utility of petroleum chemical fingerprinting in investigating known or suspected tank farm releases. A detailed characterization of groundwater was carried out in three tank farms located in north, central and south Italy. Eighteen parent polycyclic aromatic hydrocarbons (naphthalene through coronene), *n*-alkanes (n-C_{10} through n-C_{36}), isoprenoids pristane and phytane, vanadium, nickel and lead were determined. Distribution profiles and diagnostic ratios of specific fuel constituents were studied in order to identify contamination sources. Data analysis shows that in the study sites multiple pollutant sources affecting the tank farms and the surrounding industrial areas are present. Both high concentrations of contaminants coming from fuel releases and noticeable concentrations of biogenic compounds were found. A detailed data analysis suggests the origin and the level of pollution of the three sites. The results demonstrate that threshold concentration approach is not always sufficient and it is necessary to carry out studies of contaminant distribution and their diagnostic ratios in order to perform a successful forensic investigation.

08/00970 Effect of catalyst preparation and support composition on hydrodesulfurization of dibenzothiophene and Maya crude oil

Rana, M. S. *et al. Fuel*, 2007, 86, (9), 1254–1262.

Hydrodesulfurization of dibenzothiophene was carried out in a batch reactor at 3.3 MPa and 340 °C. Sulfided catalysts showed a wide range of activity variation as a function of support composition, which established that sulfided active phases strongly depend on the nature and composition of support. The incorporation of MgO, SiO_2, TiO_2 and ZrO_2 with γ-Al_2O_3 alters the nature of active phase interactions on the support surface. Therefore, these oxides play a structural promoting role to the support contribution and its interaction towards the active metal geometry. Different preparation methods of catalysts were carried out by using different additives during the impregnation. It is demonstrated that co-impregnation method found better activity than sequential impregnation. The urea additive prepared catalyst provides promising activity compared with other chelating agents. An Al_2O_3–B_2O_3 mixed oxide supported catalyst was tested at high pressure with real feed (Maya heavy oil diluted with hydrodesulfurized diesel). The mixed oxide supported catalyst showed rapid deactivation with time-on-stream than the alumina supported catalyst that may be due to an enhancement in acidic sites. The activity results demonstrated that the number of catalytic sites is a combination of support composition, additive, impregnation pH, drying and calcinations of catalysts.

08/00971 Estimation of horizontal reservoir anisotropy without type-curve matching

Escobar, F. H. *et al. Journal of Petroleum Science and Engineering*, 2008, 60, (1), 31–38.

Normally, interference testing involving at least three observation wells is used for estimation of areal anisotropy in hydrocarbon reservoirs. Current interpretation techniques are mainly based upon by pressure type-curve matching which is basically a trial-and-error procedure. This paper has been written with the purpose of overcoming this issue. Therefore, type-curve matching procedure is replaced by a pressure and pressure derivative interpretation method which follows the TDS technique philosophy, so that directional permeability can be easily estimated. The provided methodology allows to practically and accurately estimate anisotropy and carry out a quantitative estimation of both the maximum and minimum directional permeability values, and the angle formed between the x-axis and the maximum permeability semi-axis. Additionally, the average permeability value is re-estimated. A field example proposed in the literature and a synthetic example have been successfully solved for verification purposes.

08/00972 Formal description of sedimentary architecture of analogue models for use in 2D reservoir simulation

Hill, E. J. and Griffiths, C. M. *Marine and Petroleum Geology*, 2008, 25, (2), 131–141.

A formal method for describing data collected from field studies is used to generate stochastic geological models of sedimentary successions using a method based on syntactic pattern recognition. Using this method an analogue model developed from field data can be encoded as a grammar. The grammar is composed of symbols which represent geological entities. Valid patterns formed by the symbols are described by a set of production rules. In order to demonstrate the potential of the syntactic method, 2D simulations of interpreted cross-sections from Brushy Canyon outcrops are presented here, as well as 2D simulations of seismic facies from the Bengal Fan.

08/00973 Heavy oil hydroprocessing over supported NiMo sulfided catalyst: an inhibition effect by added H_2S

Rana, M. S. *et al. Fuel*, 2007, 86, (9), 1263–1269.

The influence of H_2S (0–559.6 kPa) on Maya crude hydrotreating is investigated in an integral fixed bed up-flow micro reactor. The added H_2S inhibits hydrodesulfurization (HDS) and hydrodenitrogenation while asphaltene conversion remained almost unaffected. On the other hand, a promotional effect is found for hydrodemetallization (HDM). The observed variation in HDS and HDM conversions suggests a dual nature of catalytic sites particularly at high partial pressure of hydrogen sulfide. The promotional effect for HDM may be interpreted in terms of adsorption of metal–porphyrins on Brönsted acid sites (sulfhydryl group), which enhance hydrogenation of metal–porphyrins and convert them into the corresponding metal–chlorin structure in a first step of reaction. The final step in the HDM is essentially hydrogenolysis (metal–nitrogen) and requires the presence of an anionic vacancy. The conversion of asphaltene is also depending on the acidic nature of sulfided catalyst that is remaining either uninhibited or slightly enhanced with H_2S.

08/00974 Jet fuel ignition delay times: Shock tube experiments over wide conditions and surrogate model predictions

Vasu, S. S. *et al. Combustion and Flame*, 2008, 152, (1–2), 125–143.

Ignition delay times were measured for gas-phase jet fuel (Jet-A and JP-8) in air behind reflected shock waves in a heated high-pressure shock tube. Initial reflected shock conditions were as follows: temperatures of 715–1229 K, pressures of 17–51 atm, equivalence ratios of 0.5 and 1, and oxygen concentrations of 10 and 21% in synthetic air. Ignition delay times were measured using sidewall pressure and OH* emission at 306 nm. Longer ignition delay times at low temperatures (715–850 K) were accessed by utilizing driver-gas tailoring methods. Also presented is a review of previous ignition delay time measurements of kerosene-based fuels and recent work on surrogate fuel and kinetic mechanism development. To the best of the authors' knowledge knowledge, this study reports the first gas-phase shock tube ignition delay time data for JP-8, and the measurements for Jet-A are for a broader range of conditions than previously available. The results have very low scatter and are in excellent agreement with the limited previous shock tube data for Jet-A. Although JP-8 and Jet-A have slightly different compositions, their ignition delay times are very similar. A simple $1/P$ dependence was found for ignition delay times from 874 to 1220 K for the pressure range studied for both fuels. Ignition delay time variations with equivalence ratio and oxygen concentration were also investigated. The new experimental results were compared with predictions of several kinetic mechanisms, using different jet fuel surrogate mixtures.

08/00975 Mode of occurrence and environmental mobility of oil-field radioactive material at US Geological Survey research site B, Osage-Skiatook Project, northeastern Oklahoma

Zielinski, R. A. and Budahn, J. R. *Applied Geochemistry*, 2008, 22, (10), 2125–2137.

Two samples of produced-water collected from a storage tank at US Geological Survey research site B, near Skiatook Lake in northeastern Oklahoma, have activity concentrations of dissolved ^{226}Ra and ^{228}Ra that are about 1500 disintegrations/min/L (dpm/L). Produced-water also contains minor amounts of small (5–50 μm) suspended grains of Ra-bearing $BaSO_4$ (barite). Precipitation of radioactive barite scale in the storage tank is probably hindered by low concentrations of dissolved SO_4 (2.5 mg/L) in the produced-water. Sediments in a storage pit used to temporarily collect releases of produced-water have marginally elevated concentrations of 'excess' Ra (several dpm/g), that are 15–65% above natural background values. Tank and pit waters are chemically oversaturated with barite, and some small (2–20 μm) barite grains observed in the pit sediments could be transferred from the tank or formed in place. Measurements of the concentrations of Ba and excess Ra isotopes in the pit sediments show variations with depth that are consistent with relatively uniform deposition and progressive burial of an insoluble Ra-bearing host (barite?). The short-lived $_{228}$Ra isotope (half-life = 5.76 a) shows greater reductions with depth than ^{226}Ra (half-life = 1600 a), that are likely explained by radioactive decay. The ^{228}Ra/^{226}Ra activity ratio of excess Ra in uppermost pit sediments (1.13–1.17) is close to the ratio measured in the samples of produced-water (0.97, 1.14). Declines in Ra activity ratio (excess) with sediment depth can be used to estimate an average rate of burial of 4 cm/a for the Ra-bearing contaminant. Local shallow ground waters contaminated with NaCl from produced-water have low dissolved Ra (<20 dpm/L) and also are oversaturated with barite. Barite is a highly insoluble Ra host that probably limits the environmental mobility of Ra at site B.

08/00976 On the chemical reaction between carboxylic acids and iron, including the special case of naphthenic acid

Yépez, O. *Fuel*, 2007, 86, (7–8), 1162–1168.

The reaction between different carboxylic acids and iron was performed by monitoring the amount of iron dissolved in oil through the formation of the iron carboxylate and by the product distribution in the gas phase. It was found that the solubility of the given iron carboxylate strongly influences the concentration of iron dissolved in oil. At temperatures higher than 300 °C, however, the iron carboxylate thermally decomposed and, therefore, the dissolved iron underestimates the acid corrosion potential. On the other hand, the accumulated molar amount of hydrogen gas becomes an alternative way to estimate the carboxylic acid corrosion potential.

08/00977 Recovery performance of partially fractured reservoirs by capillary imbibition

Qasem, F. H. *et al. Journal of Petroleum Science and Engineering*, 2008, 60, (1), 39–50.

Capillary imbibition is one of the major recovery mechanisms in naturally fractured reservoirs (NFR) where most of the oil is stored in tight matrix blocks. Most of the imbibition studies of NFR assume uniform fractures distribution. In reality, most of NFR are partially fractured with various degrees of fracture intensity. Studies of imbibition phenomena in partially naturally fractured reservoirs (PNFR) are not yet fully investigated. Therefore, this study examines the effectiveness of capillary imbibition phenomena for PNFR with varying degree of fracture intensity. Fracture intensity (FI) is defined as the ratio of the fractured portion of the reservoir to the total reservoir bulk volume. Furthermore, the study also sheds lights on the effect of water injection rate on the performance of PNFR. In this investigation, a random distribution of fractures is assumed to simulate irregularity in the fracture network. A dual-porosity/dual-permeability model is used to simulate the prevailing co-current and counter-current flow imbibition phenomena of the water–oil displacement process. Results show that the fracture intensity (FI) significantly affects the reservoir performance. Reservoirs with high-fracture intensity are dominated by counter-current capillary imbibition phenomena. Conversely, reservoirs with low-fracture intensity are dominated by co-current capillary imbibition phenomena. For reservoirs with intermediate-fracture intensity, both phenomena play a critical role and the recovery is adversely affected.

08/00978 Scale-up of experimental data from an isothermal bench-scale hydrotreatment plant to adiabatic reactors

Muñoz, J. A. D. *et al. Fuel*, 2007, 86, (9), 1270–1277.

A methodology for scaling-up experimental data obtained at bench-scale to a proposed process scheme, both with significant differences in configuration, is reported in this work. Four cases were developed which differentiate in operating reaction conditions and type of feedstock. The proposed approach includes validation of the bench-scale experimental results, operating conditions of equipments, and plant configuration using Hysys simulator; extrapolation of bench-scale data to the capacity of the process scheme; reactor simulation to evaluate adiabatic reactor delta-T and the number of the catalytic beds; determination of hydrogen recycle stream and composition; and hydrogen and sulfur balances. Three catalytic beds were determined for each reactor and reactors delta-T was found to be between 18 and 22 °C. The scale-up ratio was 2.7×10^5. The results are compared with experimental ones and average deviations less than 2% were obtained.

08/00979 Simulation of a spouted bed reactor for solid catalyst alkylation

Nieto, O. *et al. Fuel*, 2007, 86, (9), 1313–1324.

A process simulator was developed to afford a better understanding of the performance of a butene–isobutane alkylation plant that uses a three-phase spouted bed reactor and a super acid solid catalyst. The mass and energy balances were numerically solved using lump of reactions and kinetic expressions previously developed. The results indicate the strong influence of the gas linear velocity and temperature in the riser and downcomer behaviour that affects the activity, selectivity, and stability of the catalytic systems that cannot be predicted otherwise. The optimal operating conditions were determined for a particular catalyst and set of costs. The impacts of the recycling alkylate and isobutane to the reactor as well as the presence of hydrogen to control the coke formation are analysed.

08/00980 The transit oil and gas pipeline and the role of bargaining: a non-technical discussion

Omonbude, E. J. *Energy Policy*, 2007, 35, (12), 6188–6194.

Transit oil and gas pipelines are growing in relevance, and face a number of topical problems. One of such issues is the problem of potential disruption from a number of sources, notably post-construction behaviour of the transit country. Present and future pipelines face the risk of continuous conflict over legal, economic and political issues. Once the pipeline is built and in operation, the threat of disruption of the pipeline by the transit country over disputed transit terms exists. This is due to two key problems: first, a shift in bargaining powers to the transit country upon construction and operation of the pipeline and, second, changes in the value of the throughput imply price changes that can affect the behaviour of the transit country. This paper discusses the role of basic bargaining principles in cross-border oil and gas pipelines involving transit through one or more countries. It finds that the motive behind the pipeline plays a key role in the prevention of potential disruptions to the pipeline due to rent squeezing. Also, although the potential of such disruptions does exist, there are a number of factors that could serve to mute the consequences of shifts in bargaining power to the transit countries.

Economics, business, marketing, policy

08/00981 Biodiesel as an alternative motor fuel: production and policies in the European Union

Bozbas, K. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 542–552.

The purpose of this work is to investigate fuel characteristics of biodiesel and its production in European Union. Biodiesel fuel can be made from new or used vegetable oils and animal fats, which are non-toxic, biodegradable, renewable resources. The vegetable oil fuels were not acceptable because they were more expensive than petroleum fuels. Biodiesel has become more attractive recently because of its environmental benefits. With recent increases in petroleum prices and uncertainties concerning petroleum availability, there is renewed interest in vegetable oil fuels for diesel engines. In Europe the most important biofuel is biodiesel. In the European Union biodiesel is the by far biggest biofuel and represents 82% of the biofuel production. Biodiesel production for 2003 in EU-25 was 1,504,000 tons.

08/00982 Biofuel market and carbon modeling to analyse French biofuel policy

Bernard, F. and Prieur, A. *Energy Policy*, 2007, 35, (12), 5991–6002.

In order to comply with European Union objectives, France has set up an ambitious biofuel plan. This plan is evaluated on the basis of two criteria: tax exemption on fossil fuels and greenhouse gases emission savings. An economic marginal analysis and a life cycle assessment (LCA) are provided using a coupling procedure between a partial agro-industrial equilibrium model and an oil refining optimization model. Thus, it is determined that the minimum tax exemption needed to place on the market a targeted quantity of biofuel by deducting the biofuel long-run marginal revenue of refiners from the agro-industrial marginal cost of biofuel production. With a clear view of the refiner's economic choices, total pollutant emissions along the biofuel production chains are quantified and used to feed an LCA. The French biofuel plan is evaluated for 2008, 2010 and 2012 using prospective scenarios. Results suggest that biofuel competitiveness depends on crude oil prices and demand for petroleum products and consequently these parameters should be taken into account by authorities to modulate biofuel tax exemption. LCA results show that biofuel production and use, from 'seed to wheel', would facilitate the French government's compliance with its 'Plan Climat' objectives by reducing up to 5% GHG emissions in the French road transport sector by 2010.

08/00983 Determinants of OPEC production: implications for OPEC behavior

Kaufmann, R. K. *et al. Energy Economics*, 2008, 30, (2), 333–351.

In this paper, the authors estimate models that identify the economic and organizational determinants of crude oil production by individual OPEC nations. To clarify the interpretation of econometric results, production is modelled with specifications that resolve the statistical ordering of variables and estimate models with techniques that can cope with stochastic trends in the time series. The authors also analyse the short-run dynamics for asymmetries that may carry important insights about OPEC behaviour. Results indicate that quotas are an important determinant of production and their effects generally are symmetric, which implies that OPEC is an organization that influences production and ultimately prices. Real prices generally have a positive effect on production and the size of this effect may depend on spare capacity, which implies that OPEC behaviours also embody competitive elements. Finally all nations other than Saudi Arabia show some form of production sharing behaviour, which may imply that OPEC shares mismatches between the call for OPEC production and OPEC quotas.

08/00984 Does oilrig activity react to oil price changes? An empirical investigation

Ringlund, G. B. *et al. Energy Economics*, 2008, 30, (2), 371–396.

In this paper, the authors analyse how oilrig activity in different non-OPEC regions is affected by the crude oil price. The authors estimate relationships between oilrig activity and crude oil prices using dynamic regression models augmented with latent components capturing trend and seasonality. The results generally show a positive relationship between oilrig activity and the crude oil price, but the strength of the relationship differs across regions. Overall, there seems to be a clear relationship between the oil industry structure in the region and the oilrig activity's reaction to price changes. On average, the long-run price elasticity for oilrig activity in non-OPEC countries is around unity.

08/00985 Equitable liens and engineering, procurement and construction contracts in the oil and gas industry

Bailey, J. E. H. *Journal of Energy and Natural Resources Law*, 2007, 25, (4), 392–405.

This article considers the judgment of Colman J, sitting in the Commercial Court in London, in the case of International Finance Corporation v. DSNL Offshore Limited and Others. The case arose out of the seizure by the International Finance Corporation (IFC) of two water-injection modules and associated equipment, which were destined to be installed on a platform off the Nigerian coast. The modules were being constructed for the purchaser, Chevron Nigeria Limited, by a Nigerian contractor, DSNL Offshore Limited, under the terms of an engineering, procurement and construction (EPC) contract. The judge found that, in relation to all but one of the suppliers, the purchaser had acquired legal title to the equipment that it had bought. However, in relation to the solar equipment (which accounted for the majority of the costs of the work), the found that the contractor retained legal title at the time of seizure, notwithstanding the fact that the purchaser had paid for it. The decision is important in itself, since it represents the first time that an English court has recognized the existence of an equitable lien in relation to a contract for work and materials. However, it also represents an interesting case study of the way in which the English courts are willing to apply pragmatic solutions to disputes arising in the context of international energy projects.

08/00986 Exploration economics in a regulated petroleum province: the case of the Norwegian continental shelf

Mohn, K. and Osmundsen, P. *Energy Economics*, 2008, 30, (2), 303–320.

Reserve replacement remains a key challenge for the international oil and gas companies. As market-oriented oil and gas provinces are maturing, exploration activity is shifted towards the resource-rich, regulated regimes outside the OECD. Regulated oil and gas provinces remain under-explored also in econometric terms. In this paper, the authors specify and estimate an econometric model of exploration and appraisal drilling for the highly regulated Norwegian continental shelf over the period from 1965 to 2004. Explanatory variables include the oil price, cumulative discoveries and open exploration acreage. Estimated error-correction models account explicitly for sluggishness and short-term adjustments in exploration drilling. The authors find robust long-term oil price effects on exploration activity, whereas the short-term response is muted. On the other hand, the temporary influence on exploration drilling from licensing rounds for new exploration acreage is significant, and so are the feedback effects from historical exploration success. At the same time, the longer-term impact of these variables is more moderate.

08/00987 Heat integration analysis for an industrial ethylbenzene plant using pinch analysis

Yoon, S.-G. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 886–893.

In this study, a heat exchanger network (HEN) for an industrial ethylbenzene plant is retrofitted by pinch analysis. In the ethylbenzene process, ethylbenzene is produced by alkylation of ethylene and benzene, and the whole product is used to produce styrene monomer. From the real operating data, a HEN of the ethylbenzene process is extracted. Analysis of the HEN reveals that the current process is operated efficiently, but there is a possibility to improve the heat exchange in light removal columns. After analysis, an alternative HEN is proposed to save the energy. The alternative HEN is achieved by adding a new heat exchanger and changing operating conditions. It reduces the annual energy cost by 5.6%. In order to achieve it, the capital investment is necessary but the annual cost saving will be enough to recover the cost in less than one year.

08/00988 How does ANWR exploration affect OPEC behavior? A simulation study of an open-loop Cournot-Nash game

Yang, Z. *Energy Economics*, 2008, 30, (2), 321–332.

Exploring petroleum reserves in the Alaskan Arctic National Wildlife Refuge (ANWR) has been proposed to reduce the dependence on foreign oil and to ease the energy shortage in the United States. To investigate the impacts of the ANWR exploration on strategic behaviour of OPEC members, a calibrated dynamic model of oligopolistic competition and cartel collusion in the US petroleum market is built in this paper. Numerical simulations on an open-loop game are used here to examine the scope and magnitude of strategic interactions between OPEC's decisions and ANWR exploration. The simulation results show that OPEC's strategic postures have much stronger effects on the US petroleum market than the ANWR exploration. The simulations in this paper indicate that preventing cartel collusion by OPEC is more effective than the ANWR exploration in alleviating short petroleum supplies of the United States in the near future.

08/00989 Petroleum systems of Indonesia

Doust, H. and Noble, R. A. *Marine and Petroleum Geology*, 2008, 25, (2), 103–129.

Indonesia contains many tertiary basins, several of which have proven to be very prolific producers of oil and gas. The geology and petroleum systems of these productive basins are reviewed, summarized and updated according to the most recent developments. The recognized petroleum systems have been linked to common stages in the geological evolution of these synrift to postrift basins and classified them accordingly. The authors recognize four petroleum system types (PSTs) corresponding to the four main stages of geodynamic basin development, and developed variably in the different basins depending on their depositional environment history: (i) an oil-prone Early Synrift Lacustrine PST, found in the Eocene to Oligocene deeper parts of the synrift grabens, (ii) an oil and gas-prone Late Synrift Transgressive Deltaic PST, located in the shallower Oligocene to early Miocene portions of the synrift grabens, (iii) a gas-prone Early Postrift Marine PST, characteristic of the overlying early Miocene transgressive period, and (iv) an oil and gas-prone Late Postrift Regressive Deltaic PST, forming the shallowest late Tertiary basin fills. The petroleum systems in each of the basins have been ascribed to one of these types, recognizing that considerable mixing of the predominantly lacustrine to terrestrial charge has taken place. Furthermore, the basins have been grouped according to their predominant PSTs and identified 'basin families' that share important aspects of their hydrocarbon habitat: these have been termed proximal, intermediate, distal, Borneo and eastern Indonesian, according to their palaeogeographic relationship to the Sunda craton of Southeast Asia.

08/00990 Productivity equations for an off-center partially penetrating vertical well in an anisotropic reservoir

Lu, J. and Tiab, D. *Journal of Petroleum Science and Engineering*, 2008, 60, (1), 18–30.

This paper presents steady state and pseudo-steady state productivity equations for an off-centre partially penetrating vertical well in an anisotropic reservoir, using a uniform line sink model. This paper also gives equations for calculating pseudo skin factor due to partial penetration. Compared with the equations for partially penetrating wells in the literature, the new equations, which are based on three-dimensional models, are simple and accurate. If the well is in steady state with a circular cylinder drainage volume, and if the top and bottom reservoir boundaries are impermeable, the radius of the cylindrical system and off-centre distance appear in the productivity equations. If the reservoir has a gas cap or bottom water, the effects of the radius and off-centre distance on productivity can be ignored. A new equation is provided to calculate the productivity of a partially penetrating vertical well arbitrarily located in the anisotropic reservoir with a box-shaped drainage volume under pseudo-steady state. A convenient expression to calculate the Dietz shape factor is also presented. It is concluded that, for a partially penetrating vertical well, different productivity equations should be used under different reservoir boundary conditions.

08/00991 The oil reserves production relationship

Pickering, P. *Energy Economics*, 2008, 30, (2), 352–370.

This paper considers the relationship between the extraction rates and remaining reserves of oil. A simple exhaustible resources model suggests a linear extraction rule, with slope terms common to all extractors when discount rates are homogeneous. Differences in pricing behaviour and costs determine the intercept. Panel data from the world oil industry exhibit a robust and stable extraction–reserves relationship across countries and through time. Common slopes characterize extraction over large ranges of reserves although there is a concave relationship across non-OPEC members, and a significantly lower estimated slope within OPEC countries. These findings may be explained by risk aversion, differences in discount rates, and measurement error in the reserves data.

Derived liquid fuels

08/00992 A review of recent advances on process technologies for upgrading of heavy oils and residua

Rana, M. S. *et al. Fuel*, 2007, 86, (9), 1216–1231.

The term hydroconversion is used to signify processes by which molecules in petroleum feedstocks are split or saturated with hydrogen gas while tumbling boiling ranges and impurities content from petroleum fractions. Hydroprocessing is a broad term that includes hydrocracking, hydrotreating, and hydrorefining. To meet the gradual changes in petroleum stipulate, in particular a reduced demand for heavy fuel oil, advanced technologies for residue hydroprocessing are now extremely necessary. A refining process is needed for treating heavy petroleum fractions (atmospheric or vacuum oil residue) in the presence of catalysts and hydrogen at high pressure. In this article the different technologies for residua processing: thermal, catalytic fixed and ebullated types of hydroconversion are reviewed and discussed. A possibility of combining the advantages of these technologies together with suitable catalyst with enhanced and controlled cracking activity is also analysed.

08/00993 Characterization of liquid products obtained from co-cracking of petroleum vacuum residue with coal and biomass

Ahmaruzzaman, M. and Sharma, D. K. *Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 37–44.

Co-processing of the petroleum vacuum residue (XVR) with coal and biomass (*Calotropis procera*) has been performed in batch reactor under isothermal conditions at atmospheric pressure. The liquids obtained by co-processing have been characterized by Fourier transform infrared spectroscopy, ^{1}H nuclear magnetic resonance (NMR), ^{13}C NMR, gel permeation chromatography (GPC) and inductively coupled argon plasma (ICAP) analyses. FT-IR analysis showed that the liquid products derived from co-cracking of XVR + SC contained a few phenols, indicating that the higher hydrogen content of the XVR acted as a hydrogenation medium for the coal product in the co-cracking of the mixture. NMR analysis indicated that aromatic carbon contents decreased (about 10.8%) in the liquid products obtained from the co-cracking of XVR + SC compared to their theoretical average. GPC analysis showed that liquid products derived from co-cracking of XVR + SC are much more similar (having the almost same molecular weight distribution as XVR) to the liquid products from XVR than to the liquid products from coal, reflecting synergy in the co-cracking reaction. However, the liquid products derived from co-cracking of XVR + CL showed the liquids are comparatively more viscous than that of XVR indicating that there is a definite interaction when they are co-cracked together. It is also interesting that the liquid products obtained from co-cracking with coal and biomass contained less than 1 ppm of Ni and V, respectively. The detailed results obtained are being reported.

08/00994 HDS of straight-run gas oil at various nitrogen contents. Comparison between different reaction systems

Alvarez, A. *et al. Fuel*, 2007, 86, (9), 1240–1246.

The effect of removal extent of nitrogen-containing species on the hydrodesulfurization (HDS) of straight-run gas oil from a Mexican refinery over a NiMo-based catalyst was studied. The original middle distillate (360 ppm N) was subjected to N-compounds removal by contacting with a proprietary adsorbent. By varying contact time, feedstocks of 234 and 137 ppm N were obtained. Progressive improvement on HDS over NiMo catalyst was observed by decreasing concentration of organo-N compounds in the gas oils tested in batch reactor. However, this behaviour seemed to depend on the severity of the operation. By increasing operating temperature, the enhanced desorption rate of N-compounds relieved their poisoning effect, making less pronounced the benefit of low-nitrogen feedstocks. The HDS activity data from batch reactor were compared to those found when equivalent experiments were carried out in a fixed-bed up-flow reactor under conditions similar to those used in industrial facilities.

08/00995 Mixed alcohols synthesis from carbon monoxide hydrogenation over potassium promoted β-Mo_2C catalysts

Xiang, M. *et al. Fuel*, 2007, 86, (9), 1298–1303.

Potassium-promoted β-Mo_2C catalysts were prepared and their performances in CO hydrogenation were investigated. The main products over β-Mo_2C catalyst were C_1–C_4 hydrocarbons, only ~4 C-atom% alcohols were obtained. The products of hydrocarbons and alcohols obeyed traditional linear Anderson–Schultz–Flory (A–S–F) distribution. However, modification with K_2CO_3 resulted in a remarkable selectivity shift from hydrocarbons to alcohols. Moreover, it was found that potassium promoter enhanced the ability of chain propagation of β-Mo_2C catalysts and resulted in a higher selectivity to C_{2+}OH. For K/β-Mo_2C catalysts, the hydrocarbon products also obeyed traditional linear A–S–F plots, whereas alcohols gave a unique linear A–S–F distribution with remarkable deviation of methanol compared with that on β-Mo_2C catalyst. It could be concluded that potassium promoter might exert a prominent function on the whole chain propagation to produce alcohols. A surface phase on the K/β-Mo_2C catalysts such as the 'K–Mo–C' explained the higher value for C_{2+}OH, especially could promote the step of C_1OH to C_2OH, or could have a role in producing directly C_2OH, but again this would be speculative. At the same time, the influence of the loadings of K_2CO_3 on the performances of β-Mo_2C catalyst was investigated and the results revealed that the maximum yield of alcohol was obtained at K/Mo molar ratio of 0.2.

08/00996 Performance analysis of gas liquefaction cycles

Kanoglu, M. *et al. International Journal of Energy Research*, 2008, 32, (1), 35–43.

Relations are developed for first- and second-law analyses of the simple Linde-Hampson cycle used in gas liquefaction systems. An expression for the minimum work requirement, which is applicable to any gas liquefaction system, is developed with the help of a Carnot refrigerator. It is shown that the minimum work depends only on the properties of the incoming and outgoing gas streams and the environment temperature. Numerical calculations are performed to obtain the performance parameters of different gases while parametric studies are done to investigate the effects of liquefaction and inlet gas temperatures on various first- and second-law performance parameters. As the liquefaction temperature increases and the inlet gas temperature decreases, the liquefied mass fraction, the coefficient of performance and the exergy efficiency increase while actual and reversible work consumptions decrease. The exergy efficiency values appear to be low, indicating significant potential exists for improving efficiency and thus decreasing the required work consumption for a specified amount of liquefaction.

08/00997 The use of solvents for purifying industrial naphthalene from coal tar distilled oils

González Azpíroz, M. D. *et al. Fuel Processing Technology*, 2008, 89, (2), 111–117.

The organic chemistry industry is based on organic compounds derived from coal, petroleum and gas. Coal tars derived from the carbonization process are complex mixtures, of which the polycyclic aromatic hydrocarbons (PAHs) are the main component. One of the most important PAHs is naphthalene, which represents between 10 and 12% of the sample. In recent years, new applications for industrial naphthalene have been developed. However, the naphthalene required for high level industry must be extremely pure. New routes in the purification process are being studied to reduce the economic cost and environmental impact resulting from the increase in demand for pure naphthalene. Any alternative method to that of sublimation for purification in the distillation process and/or catalytic hydrogenation must improve the quality of industrial naphthalene, to make it suitable for the new applications. In the present work, an alternative method for purifying industrial naphthalene has been investigated. A new process based on extraction with solvents such as phosphoric acid and acetic acid is reported and discussed. Industrial naphthalene was purified by means of a new technique and the stability and good properties of the product were verified.

03 GASEOUS FUELS

Sources, properties, recovery, treatment

08/00998 A preliminary laboratory experiment on coalbed methane displacement with carbon dioxide injection

Yu, H. *et al. International Journal of Coal Geology*, 2008, 73, (2), 156–166.

CH_4/CO_2 adsorption isotherm studies on coals samples give adsorption behaviour, adsorption ratio, and other influential factors for enhanced coalbed methane recovery (ECBM) and CO_2 sequestration by CO_2 injection. Yet, they only provide static characteristics, and do not provide information on pressure-driven and concentration-driven during gas recovery and injection processes. The purpose of this study is to construct an experimental apparatus for CH_4 displacement with CO_2 injection and primarily study the basic procedure of coalbed methane (CBM), ECBM, and CO_2 sequestration at driven-conditions. An experimental apparatus was built based on the configuration of one-injection well/one-production well under ideal conditions. The apparatus was used to model CBM with CH_4 adsorption, investigate primary production of CBM and ECBM with gases desorption, and study CO_2 sequestration with its breakthrough. The change of pressure and gases amount during gases injection and desorption, and residual quantity after gases desorption were employed to ECBM and CO_2 sequestration with this equipment. The effect of CO_2 injection on CH_4 production was investigated on a small scale experimentally. The results indicate that the recovery procedure of ECBM and CO_2 sequestration with CO_2 injection can be studied with the apparatus and the gases adsorption/desorption characteristics obtained with the apparatus is obviously differ from that obtained with conventional volumetric measurement.

08/00999 An experimental study on hydrogen–methane mixtured fuels

Yilmaz, I. and Ilbas, M. *International Communications in Heat and Mass Transfer*, 2008, 35, (2), 178–187.

In this study, temperature distributions from turbulent chemical reactive flow inside a model combustor have been presented for various mixtured hydrogen–methane fuels. The gas emissions were also obtained at the combustor exit. A platinum–platinum 13% rhodium thermocouple (R type) was used for measurement of axial and radial temperatures. The axial and radial temperature measurements were taken from six various distances and four distances, respectively. Experimental measurements were made at excess air ratios of 1.2 and 1.7, two various thermal powers including 40 and 60 kW and two various hydrogen–methane blending fuels (volumetrically 30% H_2–70% CH_4 and 70% H_2–30% CH_4). The results show that the temperature level increases, CO and CO_2 emissions decrease when the hydrogen content is increased in mixtured fuel, hydrogen–methane mixtured fuels are successfully used without any important modification in natural gas burner.

08/01000 Predictions of the adsorption equilibrium of methane/carbon dioxide binary gas on coals using Langmuir and ideal adsorbed solution theory under feed gas conditions

Yu, H. *et al. International Journal of Coal Geology*, 2008, 73, (2), 115–129.

Presently many research projects focus on the adsorption and predictions of methane, nitrogen, carbon dioxide and their mixtures on coals under equilibrium gas conditions. It is highly important to develop a method for prediction of CO_2/CH_4 adsorption on coal under feed (source) gas conditions in the fields of enhanced coal bed methane recovery and CO_2 sequestration in coal bed with CO_2 injection. The objective is to develop reliable models to predict the adsorption behaviour of mixtures on coals under feed gas conditions. In this context, the adsorption and predictions of methane, carbon dioxide and three binary mixtures of these gases on two China coals under feed gas conditions have been performed on the experimental data and derived equation. Firstly, the experimental measurements of CH_4, CO_2 and their binary gas adsorption isotherms to investigate the adsorption behaviour and use for prediction of adsorption equilibrium were conducted at 301 K at pressures up to 10 MPa. Secondly, a calculation formula of adsorbed amount of total gas was derived from relation between adsorbed amount and feed gas composition at standard state on condition of unknown equilibrium gas concentration during adsorption. Thirdly, the extended Langmuir, ideal adsorbed solution (IAS) theory in conjunction with Langmuir were used to predict the experimental data of binary gas adsorption based on an iterative algorithm. Finally, the prediction accuracy for experimental data of total and adsorbed amount of component gas and free gas compositions were analysed. Experimental data indicate adsorbed amounts of the total gas and single-component CO_2 increase, but adsorbed amounts of CH_4 increase at low equilibrium pressure and decrease at high pressure with increase of CO_2 concentration in feed gas. Model predictions based on single-component isotherms and the calculation formula show that the quantitative formula obtained can be used to predict adsorption equilibrium of CH_4/CO_2 binary gas under feed gas conditions. The binary gas prediction data are quite variable and depend upon the feed gas composition. The IAS–Langmuir provides, on average, a better fit to total gas adsorption but is variable for the single-component adsorption with the feed gas composition. The predictions of total and component gas adsorption and equilibrium gas compositions illustrate similar trends with their experimental data.

08/01001 Thermal behaviour and catalytic properties towards propene combustion of zirconia modified by different first row transition metals

Lamonier, J.-F. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 20–26.

Zirconium oxyhydroxide was synthesized in the presence of different transition metals from the first row (Cr, Mn, Fe, Co, Ni, Cu) and calcined at two different temperatures 450 °C and 700 °C. Differential thermal analysis exhibits a delay in zirconia crystallization with high specific surface areas when the transition metal is associated with zirconium. Transition metals improved zirconia catalytic activity and selectivity in propene deep oxidation to CO_2 and H_2O. Catalytic activity enhancement was explained by the stabilization (total or partial) of zirconia tetragonal phase (evidenced by ambient and temperature programmed XRD studies) which leads to higher amount of anionic vacancies. The existence of reduction peaks (temperature programmed reduction with hydrogen) in the temperature range of catalytic activity explained the better catalytic performances of Cr, Mn, Co and Cu samples compared to Fe- and Ni-based ones.

Transport, storage

08/01002 Chemistry of fluids from a natural analogue for a geological CO_2 storage site (Montmiral, France): lessons for CO_2–water–rock interaction assessment and monitoring

Pauwels, H. *et al. Applied Geochemistry*, 2007, 22, (12), 2817–2833.

Chemical and isotope studies of natural CO_2 accumulations aid in assessing the chemical effects of CO_2 on rock and thus provide a potential for understanding the long-term geochemical processes involved in CO_2 geological storage. Several natural CO_2 accumulations were discovered during gas and oil exploration in France's carbogaseous peri-Alpine province (south-eastern France) in the 1960s. One of these, the Montmiral accumulation at a depth of more than 2400 m, is currently being exploited. The chemical composition of the water collected at the wellhead has changed in time and the final salinity exceeds 75 g/L. These changes in time can be explained by assuming that the fraction of the reservoir brine in the recovered brine–CO_2–H_2O mixture varies, resulting in variable proportions of H_2O and brine in the sampled water. The proportions can be estimated in selected samples due to the availability of gas and water flowrate data. These data enabled the reconstruction of the chemical and isotope composition of the brine. The proportions of H_2O and brine can also be estimated from isotope (δ^2H, $\delta^{18}O$) composition of collected water and $\delta^{18}O$ of the sulfates or CO_2. The reconstituted brine has a salinity of more than 85 g/L and, according to its Br^- content and isotope (δ^2H, $\delta^{18}O$, $\delta^{34}S$) composition, originates from an evaporated Triassic seawater that underwent dilution by meteoric water. The reconstitution of the brine's chemical composition enabled an evaluation of the CO_2–water–rock interactions based on: (1) mineral saturation indices; and (2) comparison with initial evaporated Triassic seawater. Dissolution of K- and SO_4-containing minerals such as K-feldspar and anhydrite, and precipitation of Ca and Mg containing minerals that are able to trap CO_2 (carbonates) are highlighted. The changes in concentration of these elements in the brine, which are attributed to CO_2 interactions, illustrate the relevance of monitoring the water quality at future industrial CO_2 storage sites.

08/01003 Coalbed methane reservoir data and simulator parameter uncertainty modelling for CO_2 storage performance assessment

Korre, A. *et al. International Journal of Greenhouse Gas Control*, 2007, 1, (4), 492–501.

Laboratory studies and a number of field pilots have demonstrated that CO_2 injection into coal seams has the potential to enhance coalbed methane (CBM) recovery with the added advantage that most of the injected CO_2 can be stored permanently in coal. The concept of storing CO_2 in geologic formations as a safe and effective greenhouse gas mitigation option requires public and regulatory acceptance. In this context it is important to develop a good understanding of the reservoir performance, uncertainties and the risks that are associated with geological storage. The paper presented refers to the sources of uncertainty involved in CO_2 storage performance assessment in coalbed methane reservoirs and demonstrates their significance using extensive digital well log data representing the Manville coals in Alberta, Canada. The spatial variability of the reservoir properties was captured through geostatistical analysis, and sequential Gaussian simulations of these provided multiple realizations for the reservoir simulator inputs. A number of CO_2 injection scenarios with variable matrix swelling coefficients were evaluated using a 2D reservoir model and spatially distributed realizations of total net thickness and permeability.

08/01004 Tapping the leakages: methane losses, mitigation options and policy issues for Russian long distance gas transmission pipelines

Lechtenböhmer, S. *et al. International Journal of Greenhouse Gas Control*, 2007, 1, (4), 387–395.

The Russian natural gas industry is the world's largest producer and transporter of natural gas. This paper aims to characterize the methane emissions from Russian natural gas transmission operations, to explain projects to reduce these emissions, and to characterize the role of emissions reduction within the context of current GHG policy. It draws on the most recent independent measurements at all parts of the Russian long distance transport system made by the Wuppertal Institute in 2003 and combines these results with the findings from the US Natural Gas STAR Program on GHG mitigation options and economics. With this background the paper concludes that the methane emissions from the Russian natural gas long distance network are approximately 0.6% of the natural gas delivered. Mitigating these emissions can create new revenue streams for the operator in the form of reduced costs, increased gas throughput and sales, and earned carbon credits. Specific emissions sources that have cost-effective mitigation solutions are also opportunities for outside investment for the Joint Implementation Kyoto Protocol flexibility mechanism or other carbon markets.

08/01005 Thermal analysis of adsorptive natural gas storages during dynamic charge phase at room temperature

Ridha, F.N. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 14–22.

The thermal behaviour of an adsorptive natural gas (ANG) vessel pressurized continuously with light hydrocarbon gases and their mixture at 27 °C was analysed using two different activated carbons. Activated carbon AC-L showed better isothermal storage capacity than AC-D due to its sufficient porous structure. However, higher adsorption capacity claimed more extreme thermal fluctuation represented by a temperature rise of 99.2 °C at the centre region of the bed charged continuously with methane at $1\,L\,min^{-1}$ up to pressure of 4 MPa, corresponding to 82.5 °C in AC-D bed. Higher charge rate of $5\,L\,min^{-1}$ claimed severer thermal fluctuation of 116 °C in AC-L/methane system calling for a serious reduction of 26.9% in the dynamic storage capacity with respect to the isothermal storage capacity. This reduction brought the storage system to a working pressure of about 2.5 MPa rather than the desired working pressure of ~4 MPa (about 40% reduction in storage pressure). The severest temperature rise was at the centre region caused by bed poor thermal conductivity leading to limited heat transfer. High ethane and propane portions in natural gas may contribute to the thermal fluctuation of the storage system as their heats of adsorption are higher than that for methane.

Economics, business, marketing, policy

08/01006 A complementarity model for solving stochastic natural gas market equilibria

Zhuang, J. and Gabriel, S. A. *Energy Economics*, 2008, 30, (1), 113–147.

This paper presents a stochastic equilibrium model for deregulated natural gas markets. Each market participant (pipeline operators, producers, etc.) solves a stochastic optimization problem whose optimality conditions, when combined with market-clearing conditions give rise to a certain mixed complementarity problem (MiCP). The stochastic aspects are depicted by a recourse problem for each player in which the first-stage decisions relate to long-term contracts and the second-stage decisions relate to spot market activities for three seasons. Besides showing that such a market model is an instance of a MiCP, theoretical results are provided concerning long-term and spot market prices and solve the resulting MiCP for a small yet representative market. The authors also note an interesting observation for the value of the stochastic solution for non-optimization problems.

Derived gaseous fuels

08/01007 A study on pyrolytic gasification of coffee grounds and implications to allothermal gasification

Mašek, O. *et al. Biomass and Bioenergy*, 2008, 32, (1), 78–89.

The increasing interest in biomass, as a renewable source of energy, is stimulating a search for suitable biomass resources as well as the development of technologies for their effective utilization. This work concentrated on characteristics of processes occurring during pyrolytic gasification of upgraded food industry residues, namely residue from industrial production of liquid coffee, and assessed its suitability for conversion in an allothermal gasifier. The influence of several operating parameters on product composition was examined with three different laboratory-scale reactors, studying the primary pyrolysis and secondary pyrolysis of nascent volatiles, and the steam gasification of char. The experimental results show that a high degree of conversion of UCG into volatiles and gases (up to 88% C-basis) can be achieved by fast pyrolysis even at temperatures as low as 1073 K. In addition, the degree of conversion is not influenced by the presence or concentration of steam, which is an important factor in allothermal gasification. Mathematical simulation of an allothermal gasifier showed that net cold-gas efficiency as high as 86% can be reached.

08/01008 Investigation into a catalytically controlled reaction gasifier (CCRG) for coal to hydrogen

Castaldi, M. J. and Dooher, J. P. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4170–4179.

Energy demands will increase as industrialized nations strive to maintain progress and productivity gains and as developing nations increase their consumption and productivity. One direction that is evolving to satisfy the demand while minimizing environmental impacts is to move toward a hydrogen economy. For the foreseeable future, the majority of these demands will be met through the increased usage of fossil fuels. One of the most abundant and readily available fuels is coal. This realization has raised some questions about the responsible use of such a fuel and as such it is critical that a Greenhouse Gas Management strategy/technology be developed to forestall projected global warming and its impacts. The technology presented in this paper involves a novel form of coal gasification to convert coal to useful forms of energy while addressing environmental concerns. The technology, which is a form of steam reforming, focuses on the combining of catalytic combustion with coal gasification to generate H_2 and CO from coal while yielding a CO_2 sequestration ready stream. The H_2 can either be separated from the CO or used as an IGCC turbine fuel. Using an Aspen Plus simulation shows that with a steam to carbon ratio of 1.5 provides a hydrogen output of 1.15 kg/h while generating about 14 kW of electricity (for every 1 kmol/h of carbon fed to the reformer) from a SOFC using the portion of the CO generated which was not needed to drive the reforming reactions. Additionally, recycling up to 25% of CO_2 into the reformer produces about 15% more hydrogen, while using 20% less CO for combustion to drive the gasification reactions. Because of the Boudouard reaction an extra 32% (4.5 kW per kmol/h of carbon) can be generated from an SOFC operating on the CO not used for combustion.

08/01009 Micro-channel reactor for steam reforming of methanol

Kundu, A. *et al. Fuel*, 2007, 86, (9), 1331–1336.

Micro-channel reactor for steam reforming of methanol seems to be attractive for portable application as one part of fuel processor in fuel cell. In the present study, steam reforming of methanol was performed in one stainless steel micro-channel reactor coated with commercial catalyst. The different sols (alumina, zirconia and mixed sol of alumina and zirconia) as a binder for the catalyst were applied to compare the stability and performance. Among the different sols, mixed sol of alumina and zirconia comparatively produced better stability and performance.

08/01010 Performance evaluation of an agricultural residue-based modular throat-type down-draft gasifier for thermal application

Pathak, B. S. *et al. Biomass and Bioenergy*, 2008, 32, (1), 72–77.

A 125 kg h^{-1} biomass gasifier of modular design was developed at the Sardar Patel Renewable Energy Research Institute (SPRERI) and tested on the thermal mode to test the concept. Based on these studies, a scaled-up 375 kg h^{-1} modular throat type, down-draft gasifier system was designed, developed and tested. The performance of the two systems is discussed in this paper. The smaller gasifier when tested at a wood consumption rate of 55 kg h^{-1} gave a gas calorific value of 4.24 MJ N m^{-3} and cold gas gasification efficiency of 63%. The larger gasifier system was operated for about 50 h using agro-residues briquettes at gas flow rates of 213 and 278 N m^3 h^{-1}. The cold gas efficiency was in the range of 70–73%. The gasifier was also operated at a gas flow rate of 460 N m^3 h^{-1} using wood as feedstock at a cold gas efficiency of 71%. The gasifier system was also tested continuously for 10 h without any problem and it produced good quality of gas consistently.

08/01011 Supercritical gasification of wastewater from updraft wood gasifiers

Di Blasi, C. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 802–811.

Supercritical water gasification (SCWG) of the wood tar fraction soluble in water is discussed. The mixture is collected downstream of an updraft wood gasification plant and presents tar compounds typical of low-temperature pyrolysis, with the highest yields attained by acetic acid, levoglucosan and 1-hydroxy-2-propanone. SCWG tests, using a laboratory-scale reactor with a plug-flow behaviour, temperatures of 723–821 K, residence times of 46–114 s and initial total organic carbon (TOC) contents of 6.5–31 g/l (pressure equal to 25 MPa), show TOC conversion roughly between 30% and 70%. The corresponding yields of gas (l) with respect to the initial TOC contents (g) vary from 0.4 to 1. Gasification of TOC is well described by an irreversible, first-order, Arrhenius rate reaction with an activation energy of 75.7 ± 22 kJ/mol and a pre-exponential factor of $897 \pm 30\,s^{-1}$. Quantification of 23 tar compounds of the product stream shows the prompt conversion of sugars and complex phenols, with the formation of intermediate products, such as furfurals, which successively decompose, and more thermally resistant species, such as acetic acid, propionic acid, 1,2-ethanediol, ketones and especially cresols and phenols.

LNG

08/01012 Analysis of rock drainage and cooling experiments for underground cryogenic LNG storage

Cha, S.-S. *et al. Engineering Geology*, 2007, 93, (3–4), 117–129.

Hydrogeological monitoring was conducted around a pilot cavern for underground cryogenic LNG (liquefied natural gas) storage. The monitoring was mainly focused on the operation of a drainage and recharge system. After the operation of the drainage system commenced, the drainage rate decreased rapidly in the initial stages and then decreased gradually. Hydrogeological monitoring revealed that the rock drainage system operated effectively. During drainage, the water table was maintained below the cavern roof. The recharge for ice-ring formation was performed in two phases. The first phase involved the cessation of pumping in downward-drainage holes and the second involved the closure of upward boreholes. Since the water table was maintained below the cavern roof, artificial recharge was planned at first. However, it was not implemented due to heavy rainfall in the recharge stage. On the basis of hydrogeological monitoring and hydraulic tests, it was found that the fractures above the roof and on the right wall of the pilot cavern mainly affected seepage into the cavern and thermal variation due to the storage of liquid nitrogen. Thermal variation was examined by the thermometers installed around the pilot cavern. The cooling and thawing processes reveal the characteristics of thermal distribution in the rock and the 0 °C isotherm. The cooling phase lasted for six months, and the 0 °C isotherm progressed in time after the injection of liquid nitrogen into the cavern. The isotherm propagated up to about 4 m from the floor and the sidewall of the cavern and about 3 m from the cavern roof. The cooling rate of the rock mass above the cavern roof was lower than that of the other cavern sides due to the gaseous space in the upper part of the containment. The fractures were analysed and considered for thermal modelling. A two-dimensional finite element analysis was performed to compare the field monitoring at the pilot cavern. The numerical modelling shows the distance between the ice ring and heat transfer pattern of the fractures around the pilot cavern. The propagation of the measured and calculated 0 °C isotherm reveals that the water-conveying joint on the right wall might affect thermal propagation through a thermal pipe.

08/01013 Borehole radar investigations for locating ice ring formed by cryogenic condition in an underground cavern

Kim, J.-B. *et al. Journal of Applied Geophysics*, 2007, 62, (3), 204–214.

A small underground pilot plant was constructed and operated at the Korea Institute of Geoscience and Mineral Resources for investigating the feasibility of a new concept of storing liquefied natural gas (LNG) in a lined hard rock cavern. In the operation of the pilot plant, liquid nitrogen was stored instead of LNG for safety purpose. A drainage system controlled the development of an impervious ring of ice formed due to storage of liquid nitrogen in extremely low temperature. The ice ring formed around the storage cavern was very important because this can act as the final barrier to secure the LNG storage. The authors carried out borehole radar surveys to study the applicability of the borehole radar reflection method to locating the ice ring formation. Prior to conducting the fieldwork, numerical experiments of borehole radar reflection survey were performed; through the analysis of the numerical modelled data the most appropriate interpretation strategies for locating the ice rings were obtained. Before and after storing the liquid nitrogen in the underground cavern, borehole radar reflection and crosshole level scanning surveys were conducted. The data obtained at the two stages of the surveys were compared in order to identify changes occurring in basement rock after storing the liquid nitrogen. The interpretation of the borehole radar data clearly showed that the ice rings only developed under and in front of the LNG storage cavern of the pilot plant, but not over it. Through the numerical modelling experiments and field monitoring exercises, borehole radar reflection technique was found to be an effective method for locating ice rings formed in basement rock for storing material of extremely low temperature in an underground cavern.

08/01014 Sensitivity of extreme hydroelastic load effects to changes in ship hull stiffness and structural damping

Wu, M. and Moan, T. *Ocean Engineering*, 2007, 34, (11–12), 1745–1756.

In this paper, a new hybrid method for the time-domain non-linear simulation of the hydroelastic load effects and the peak over threshold (POT) method for the calculation of the short-term extreme responses are briefly described and applied to a flexible SL-7 class containership and a flexible liquefied natural gas (LNG) ship. Three stiffness levels, three stiffness distributions and three modal damping ratios were used to study the influence of the hull flexibility and structural damping on the short-term prediction of extreme vertical hydroelastic load effects. The results give justification for some simplified treatment of the first vertical flexible mode in early design stage when structural details are not available.

08/01015 Thermodynamic analysis of an LNG fuelled combined cycle power plant with waste heat recovery and utilization system

Shi, X. and Che, D. *International Journal of Energy Research*, 2007, 31, (10), 975–998.

This paper has proposed an improved liquefied natural gas (LNG) fuelled combined cycle power plant with a waste heat recovery and utilization system. The proposed combined cycle, which provides power outputs and thermal energy, consists of the gas/steam combined cycle, the subsystem utilizing the latent heat of spent steam from the steam turbine to vaporize LNG, the subsystem that recovers both the sensible heat and the latent heat of water vapour in the exhaust gas from the heat recovery steam generator (HRSG) by installing a condensing heat exchanger, and the HRSG waste heat utilization subsystem. The conventional combined cycle and the proposed combined cycle are modelled, considering mass, energy and exergy balances for every component and both energy and exergy analyses are conducted. Parametric analyses are performed for the proposed combined cycle to evaluate the effects of several factors, such as the gas turbine inlet temperature (TIT), the condenser pressure, the pinch point temperature difference of the condensing heat exchanger and the fuel gas heating temperature on the performance of the proposed combined cycle through simulation calculations. The results show that the net electrical efficiency and the exergy efficiency of the proposed combined cycle can be increased by 1.6 and 2.84% than those of the conventional combined cycle, respectively. The heat recovery per kg of flue gas is equal to $86.27\,\mathrm{kJ\,s^{-1}}$. One MW of electric power for operating sea water pumps can be saved. The net electrical efficiency and the heat recovery ratio increase as the condenser pressure decreases. The higher heat recovery from the HRSG exit flue gas is achieved at higher gas TIT and at lower pinch point temperature of the condensing heat exchanger.

Hydrogen generation and storage

08/01016 Comparison of environmental and economic aspects of various hydrogen production methods

Kothari, R. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 553–563.

A wide variety of processes are available for hydrogen production from gaseous or liquid fuels. They differ according to the nature of the primary fuel used (ammonia, methanol, ethanol, gaseous or liquid hydrocarbons, water) and to the chemical reactions involved (decomposition, steam reforming, partial oxidation, electrolysis, gasification). As recent technology progress makes hydrogen a realistic long-term energy option with little or no pollution, developments of new methods for its production and improvement of conventional technology are important. This paper analyses the recent development of hydrogen production technologies followed by an overview of conventional and renewable energy sources and a discussion about enviro-economic aspects for hydrogen production methods. The results show that although renewable energy resources cannot entirely satisfy the energy demand but electrolysis associated with solar energy, wind power, hydropower and biomass are available renewable sources for significant hydrogen production.

08/01017 Design and fabrication of carbon nanotube-based microfuel cell and fuel cell stack coupled with hydrogen storage device

Reddy, A. L. M. and Ramaprabhu, S. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4272–4278.

A metal hydride-based hydrogen storage device capable of storing 70 l of hydrogen reversibly at ambient conditions with 500 g of $ZrMn_{0.85}Cr_{0.1}V_{0.05}Fe_{0.5}Ni_{0.5}$ has been designed and developed. Good quality of multiwalled carbon nanotubes (MWNTs) have been synthesized by pyrolysis of acetylene over hydrogen decrepitated alloy hydride catalyst. Pt-supported MWNTs (Pt/MWNTs) electrocatalysts have been prepared by chemical reduction method using functionalized MWNTs. Fabrications of a fuel cell stack and a planar configured microfuel cell have been done using membrane electrode assembly prepared with Pt/MWNTs electrocatalyst and Nafion 1135 membrane. Performance studies of fuel cell stack and microfuel cell were done by coupling them to hydrogen storage device followed by demonstration of the working of electronic devices.

08/01018 Hydrogen storage by carbon materials synthesized from oil seeds and fibrous plant materials

Sharon, M. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4238–4249.

Carbon materials of various morphologies have been synthesized by pyrolysis of various oil-seeds and plant's fibrous materials. These materials are characterized by SEM and Raman. Surface areas of these materials are determined by methylene blue method. These carbon porous materials are used for hydrogen storage. Carbon fibres with channel type structure are obtained from baggas and coconut fibres. It is reported that amongst the different plant based precursors studied, carbon from soyabean (1.09 wt%) and baggas (2.05 wt%) gave the better capacity to store hydrogen at $11\,\mathrm{kg/m^2}$ pressure of hydrogen at room temperature. Efforts are made to correlate the hydrogen adsorption capacity with intensities and peak positions of G- and D-band obtained with carbon materials synthesized from plant based precursors. It is suggested that carbon materials whose G-band is around $1575\,\mathrm{cm^{-1}}$ and the intensity of D-band is less compared to G-band, may be useful material for hydrogen adsorption study.

08/01019 Hydrogen storage in boron substituted carbon nanotubes

Sankaran, M. and Viswanathan, B. *Carbon*, 2007, 45, (8), 1628–1635.

Template assisted synthesis of boron substituted carbon nanotubes was carried out by the carbonization of hydroborane polymer in alumina membrane template. The nanotubes were characterized by electron microscopic analysis, FT-Raman, FT-IR, XRD, X-ray photoelectron spectroscopy (XPS) and ^{13}C and ^{11}B MAS NMR techniques. The presence of boron in different chemical environment has been visualized by XPS and ^{11}B MAS NMR. The hydrogen absorption activity has been studied and a maximum of 2 wt% hydrogen storage capacity was observed.

08/01020 Hydrogen storage in capillary arrays

Zhevago, N. K. and Glebov, V. I. *Energy Conversion and Management*, 2007, 48, (5), 1554–1559.

The authors have developed the technology of hydrogen storage in capillary arrays, and corresponding theoretical background was presented. The technology can be effectively used for safe transportation and storage of highly pressurized hydrogen in mobile systems, ranging from domestic electronic devices to ground and sea vehicles.

08/01021 Statistical validation and an empirical model of hydrogen production enhancement found by utilizing passive flow disturbance in the steam-reformation process

Erickson, P. A. and Liao, C.-H. *Experimental Thermal and Fluid Science*, 2007, 32, (2), 467–474.

A passive flow disturbance has been proven to enhance the conversion of fuel in a methanol-steam reformer. This study presents a statistical validation of the experiment based on a standard 2^k factorial experiment design and the resulting empirical model of the enhanced hydrogen producing process. A factorial experiment design was used to statistically analyse the effects and interactions of various input factors in the experiment. Three input factors, including the number of flow disturbers, catalyst size, and reactant flow rate were investigated for their effects on the fuel conversion in the steam-reformation process. Based on the experimental results, an empirical model was developed and further evaluated with an uncertainty analysis and interior point data.

08/01022 Thin film *n*-titanium oxide photoanodes for photoelectrochemical production of hydrogen

Arakelyan, V. M. *et al. Renewable energy*, 2008, 33, (2), 299–303.

The semiconductor photoanodes made of thin film titanium oxide were prepared at room temperature by anodization of titanium plates in the hydrofluoric acid solution at direct bias. The influence of the change of the titanium oxide film growth conditions (concentration of hydrofluoric acid, voltage, duration of anodization process) and subsequent heat treatment of films on the photocurrent and current–voltage characteristics of photoelectrodes were investigated. The influence of the electrolyte concentration change on photoelectrochemical behaviour of thin film titanium oxide photoanodes was investigated.

04 BY-PRODUCTS RELATED TO FUELS

08/01023 A study of characteristics of activated carbon produced from Jordanian olive cake

Aljundi, I. H. and Jarrah, N. *Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 33–36.

Agricultural by-products, such as olive cake, contribute large quantities of waste to the environment each growing season. The objective of this study was to convert olive cake to activated carbon for use in adsorption of metal ions, such as cadmium. Milled olive cake was pyrolysed in an inert atmosphere of nitrogen gas, and activated with carbon dioxide at different temperatures ranging from 500 to 700 °C. Scanning electron microscope revealed that high porosity was obtained at 600 °C when the raw material was impregnated with $ZnCl_2$ which was proved by the surface area measured by nitrogen adsorption at 77 K and calculated by BET equation. The prepared carbons were evaluated for their adsorption capacity of cadmium. The adsorption isotherms were measured in batch experiments. The experimental data were analysed by both Freundlich and Langmuir isotherm models. The maximum adsorption capacity of cadmium calculated from Langmuir isotherm was around 20 mg/g using combined activation. This study demonstrates that olive cake can serve as a source for AC with metal ion-removing potential and may serve as a replacement for coal-based commercial carbons in applications that warrant their use.

08/01024 Activated carbon from olive kernels in a two-stage process: Industrial improvement

Zabaniotou, A. *et al. Bioresource Technology*, 2008, 99, (2), 320–326.

Activated carbons have been prepared from olive kernels and their adsorptive characteristics were investigated. A two stage process of pyrolysis-activation has been tested in two scales: (a) laboratory scale pyrolysis and chemical activation with KOH and (b) pilot/bench scale pyrolysis and physical activation with H_2O–CO_2. In the second case, olive kernels were first pyrolysed at 800 °C, during 45 min under an inert atmosphere in an industrial pyrolyser with a throughput of 1 t/h (Compact Power Ltd., Bristol, UK). The resulting chars were subsequently activated with steam and carbon dioxide mixtures at 970 °C in a batch pilot monohearth reactor at NESA facility (Louvain-la Neuve, Belgium). The active carbons obtained from both scales were characterized by N_2 adsorption at 77 K, methyl-blue adsorption (MB adsorption) at room temperature and SEM analysis. Surface area and MB adsorption were found to increase with the degree of burn-off. The maximum BET surface area was found to be around 1000–1200 m^2/g for active carbons produced at industrial scale with physical activation, and 3049 m^2/g for active carbons produced at laboratory with KOH activation. The pores of the produced carbons were composed of micropores at the early stages of activation and both micropores and mesopores at the late stages. Methylene blue removal capacity appeared to be comparable to that of commercial carbons and even higher at high degrees of activation.

08/01025 Activated carbon supported Ni–Ca: influence of reaction parameters on activity and stability of catalyst on methane reformation

Díaz, K. *et al. Fuel*, 2007, 86, (9), 1337–1344.

The objective of the present work was to study the influence of some reaction parameters (temperature, chemical nature of pre-treatment gas, mass catalyst) on the yield of methane reforming with carbon dioxide on Ni (5%)–Ca (1%)/AC at atmospheric pressure. The obtained results show that the best system was pre-treated under He flow at 650 °C and then following the reaction at the same temperature. It was also detected that Ca plays a co-support role inhibiting the deactivation of catalyst at long periods of reaction. It can be concluded that it is possible to employ activated carbon as support for methane dry reformation obtaining representative methane conversions up to 40% at mild experimental conditions.

08/01026 Activated fly ash/slag blended cement

Zhao, F.-Q. *et al. Resources, Conservation and Recycling*, 2007, 52, (2), 303–313.

This paper presents the results of the preparation of an ecological cementing material from granulated blast-furnace slag (GBFS) and Class C fly ash (CCFA). The desulfurization gypsum, calcined at 600–800 °C for 0.5–1.5 h, works as the main ingredient of the activator in the cementing material. The optimized formulation of the cementing material was obtained with the aid of factorial design method: slag, 70%; CCFA, 18%; activator, 12%. The 'partial super-fine grinding process' was adopted to improve the performance, i.e. 85% of the mixture is ground to Blaine fineness of 3500 cm^2/g, 15% further ground to around 5000 cm^2/g. The compressive strength of 28 days of the cement mortar is up to 49 MPa and flexural strength 8.4 MPa. The hydration products, investigated by SEM and X-ray diffraction, are mainly ettringite and C–S–H gel.

08/01027 Fly ash–airborne particles from Ptolemais–Kozani area, northern Greece, as determined by ESEM-EDX

Iordanidis, A. *et al. International Journal of Coal Geology*, 2008, 73, (1), 63–73.

The aim of this study is to investigate the contribution of fly ash from lignite-fired power stations to the air pollution of the Western Macedonia region of northern Greece. Several filters that capture airborne particles were collected over the period of a year (March 2003 to February 2004), from seven sampling sites spread throughout the area. In addition, fly ash was collected from two power plants in this area along with stack ash (fly ash that escaped the electrostatic precipitators and trapped at the stack's exit). Both fly ash and filters were analysed with the help of environmental scanning electron microscopy (ESEM), coupled with energy dispersive X-ray analysis (EDX) in order to determine the morphological, mineralogical and chemical characteristics of fly ash particles. Cenospheres, vesicular spheres, spheroids, dense spheres and chars were the main recognized fly ash particles. Similar airborne particles were also present in almost every filter collected in the area. Sampling sites situated nearby power plants had apparently more fly ash particles. Fine fly ash particles (<5 μm) were transported to distant sites, while larger fly ash particles (≥ 10 μm) were mostly recorded in the vicinity of power stations. The analysis also revealed the presence of potential toxic elements in the fly ash, a fact with important environmental implications.

08/01028 The reduction and control technology of tar during biomass gasification/pyrolysis: an overview

Han, J. and Kim, H. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 397–416.

Biomass is an important primary energy source as well as renewable energy source. As the most promising biomass utilization method, gasification/pyrolysis produces not only useful fuel gases, char and chemicals, but also some byproducts like fly ash, NO_x, SO_2 and tar. Tar in the product gases will condense at low temperature, and lead to clogged or blockage in fuel lines, filters and engines. Moreover, too much tar in product gases will reduce the utilization efficiency of biomass. Therefore, the reduction or decomposition of tar in biomass derived fuel gases is one of the biggest obstacles in its utilization for power generation. In this paper, the authors review the literatures pertaining to tar reduction or destruction methods during biomass gasification/pyrolysis. On the basis of their characteristics, the current tar reduction or destruction methods can be broadly divided into five main groups: mechanism methods, self-modification, thermal cracking, catalyst cracking and plasma methods.

05 NUCLEAR FUELS

Scientific, technical

08/01029 Pre-design of Magnum-PSI: a new plasma–wall interaction experiment

van Eck, H. J. N. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1878–1883.

The FOM-Institute for Plasma Physics Rijnhuizen is preparing the construction of Magnum-PSI, a magnetized (3 T), steady state, large area (80 cm^2) high-flux (up to 10^{24} H^+ ions m^{-2} s^{-1}) plasma generator. The aim of the linear plasma device Magnum-PSI is to provide a controlled, highly accessible laboratory experiment in which the interaction of a magnetized plasma with different surfaces can be studied in detail. Plasma parameters can be varied over a wide range, in particular covering the high-density, low-temperature conditions expected for the detached divertor plasma of ITER. The target set-up will be extremely flexible allowing the investigation of different materials under a large variety of conditions (temperatures, inclination, biasing, coatings, etc.). A range of target materials will be used, including carbon, tungsten and other metals, and mixed materials. Because of the large plasma beam of 10 cm diameter and spacious vacuum tank, even the test of whole plasma-facing component mock-ups will be possible. This article presents the pre-design of the Magnum-PSI experiment and focuses on the requirements of the vacuum system and the 3 T superconducting magnet. Some of the other sub-systems on Magnum-PSI, such as the target and target manipulator, are briefly introduced.

08/01030 A model for the analysis of pump start-up transients in Tehran research reactor

Farhadi, K. *et al. Progress in Nuclear Energy*, 2007, 49, (7), 499–510.

During the starting up period of a centrifugal pump the rotational speed is accelerated rapidly from standstill to its final speed and then established at the rated speed. While flow rate and total dynamic pressure rise are boosted accordingly. In the point of view of a theoretical treatment, pump start-up offers difficulty because both rotational speed and flow rate are variable. A far more difficulty is the linearization of the pump speed which is fundamentally impossible. Since a change in speed of the pump is one of transients cause leading to variation in the pressure and discharge. In order to predict the behaviour of the pump during start-up transient condition a mathematical model is developed. The model is based on a working practical approximation in that the total start-up time is reduced by one third. The influence of the two most important parameters, kinetic energy in the piping system and kinetic energy of the pump, is taken into account in the form of a ratio called hereafter an effective energy ratio. Preliminary test of the model was made on the existing piping systems related to nuclear reactors. As a case of study the safety of the Tehran research reactor (TRR) primary piping system, an open pool MTR-type research reactor, is considered. It is demonstrated that, by comparing the curves resulted from the numerical solution of the model in which design data of the TRR are used with the experimental characteristics curves of the TRR, the possibility of primary coolant pump turbining is exceptional.

08/01031 Another option for separated plutonium management: storage MOX

Macfarlane, A. M. *Progress in Nuclear Energy*, 2007, 49, (8), 644–650.
Currently there is no plan for the management of civilian plutonium that does not create a stockpile of separated plutonium. As a result, a number of nations with nuclear technology hold a large stockpile (about 240 tonnes) of separated plutonium. This paper suggests a timely, cost-effective solution for managing this material: storage MOX. A storage MOX plan would use existing MOX fuel fabrication facilities to make a simple MOX waste form suitable for long-term storage. Alternative waste forms to MOX are also possible, such as zirconia and pyrochlore, which provide more reliable durability and radiation damage control over thousands to hundreds of thousands of years.

08/01032 Burnup studies of spent fuels of varying types and enrichment

Ansari, S. A. *et al. Annals of Nuclear Energy*, 2007, 34, (8), 641–651.
This paper describes the results of fuel burnup measurements, made over a period of several years on discharged fuel from nuclear power plant and research reactor. The measured and calculated burnup of different spent fuel types, viz.: Natural uranium CANDU fuel bundles; 10.5% enriched booster rods; 20% enriched MTR fuel elements have been presented. High-resolution gamma spectrometry, using ^{137}Cs and ^{134}Cs burnup monitors was employed in different reactors to estimate the amount of ^{235}U depletion in the respective fuel. The experimental data was compared with those of calculations to optimize fuel-scheduling programme. The burnup data is useful for assessment of fuel performance in the core and resolving design issues related to long-term storage facilities. It has been observed that the gamma spectrometry is very effective in identifying exact position of individual booster bundles inside the discharged booster assemblies, which is useful in safeguard applications. It is concluded that the distribution of measured isotopic activity ratios of ^{134}Cs/^{137}Cs along the height of the spent fuel gives accurate estimate of the axial neutron flux profiles in the core. The activity ratio technique therefore provides a useful method to determine flux peaking factors at the particular locations of the fuel assemblies in the reactor.

08/01033 Detailed characterisations of high burn-up structures in oxide fuels

Noirot, J. *et al. Journal of Nuclear Materials*, 2008, 372, (2–3), 318–339.
In this paper, a series of post-irradiation examination results on high burn-up structures (HBS) are summarized for a wide variety of fuels (various programmes on PWR UO_2 fuels with different claddings and with or without doping, PWR MOX fuels, FBR fuels, etc.). This summary is intended to provide a better understanding of how high burn-up structure is formed and subsequently changes up to very high burn-ups in various irradiation conditions. This paper also focuses on the existence of planar defects prior to the HBS formation and their change with time, as well as on the chemical influences and consequences of the HBS. Two new mechanisms are proposed to take into account these observations.

08/01034 Fast brazing development for the joining of the beryllium armour layer for the ITER first wall panels

Boudot, C. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1639–1644.
This paper describes the development of a flat pancake inductor for brazing beryllium tiles on a primary first wall (PFW) panel heat sink as well as the development of the brazing parameters. Two main variables were tested: brazing filler metal on one hand and PVD coating material on beryllium tiles on the other hand. The nickel coating and silver base brazing filler metal was the best couple and obtained shear values higher than 100 MPa. The inductor design and the choice of materials were applied to the brazing of a mock-up for high heat flux testing. Some tiles sustained 1000 cycles at 1.5 MW.

08/01035 Fission-enhanced diffusion in dispersion fuels

Olander, D. *Journal of Nuclear Materials*, 2008, 372, (1), 94–105.
Irradiation-induced diffusion in finite, two-phase systems is analysed and applied to the geometry of dispersion fuels of the type used in research and test reactors. A fissioning sphere irradiates the surrounding medium in which fission also takes place. In place of the fission rate used in conventional irradiation-induced diffusion coefficient (D^*) correlations, the energy deposition rates due to electronic and nuclear stopping of the fission fragments are separated. The former is used to drive the point-defect contribution to D^* and the latter is the source of the thermal-spike component. This separation accounts for the preponderance of electronic energy loss early in the track of a fission-fragment and the dominance of nuclear stopping near the end of the range. This distinction accounts for the difference in the relative intensities of these two energy loss modes in a fission-fragment that exits one phase and deposits energy in an adjacent medium in which D^* is to be determined. Fission-fragment stopping powers and projected ranges are obtained from SRIM software, thereby permitting extraction of the two types of energy deposition rates from the fission rate. As expected, the ratio of nuclear stopping to electronic stopping in the medium surrounding a fissioning inclusion increases with distance from the interface. The effective irradiation-enhanced diffusivity for use in the diffusion equation depends upon two parameters: the fraction of D^* in an infinite, homogeneous solid attributable to nuclear stopping and the ratio of the volumetric fission rates in the dispersed and continuous phases.

08/01036 High heat flux testing of a helium-cooled tungsten tube with porous foam

Youchison, D. L. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1854–1860.
Utramet, Inc. fabricated one-piece heat exchanger tubes of chemical vapour deposited (CVD) tungsten (W), each with an internal porous mesh fused along either 51 or 38 mm of the axial length of a tube 15 mm in outer diameter. The open porous mesh has a structure of joined ligaments that combines relatively low resistance to flow and a large area for heat transfer. In tests at the Electron Beam Test Stand (EBTS) at Sandia National Laboratories, the maximum absorbed heat load was 22.4 MW/m^2 with helium at 4 MPa, flowing at 27 g/s and with inlet and outlet temperatures of 40 and 91 °C and a pressure drop of ~0.07 MPa. The preparation and testing of the samples was funded through a Phase I grant by the US Department of Energy's Small Business Innovation Research Program. The paper reports the surface temperature distribution indicated by an infrared camera, test conditions, a post-test examination in a scanning electron microscope and other details.

08/01037 High temperature thermal properties for metals used in LWR vessels

Rempe, J. L. and Knudson, D. L. *Journal of Nuclear Materials*, 2008, 372, (2–3), 350–357.
Because of the impact that melt relocation and vessel failure has on subsequent progression and associated consequences of a light water reactor (LWR) accident, it is important to accurately predict the heatup and relocation of materials within the reactor vessel and heat transfer to and from the reactor vessel. Accurate predictions of such heat transfer phenomena require high temperature thermal properties. However, a review of vessel and structural steel material properties in severe accident analysis codes reveals that the required high temperature material properties are extrapolated with little, if any, data above 700 °C. To reduce uncertainties in predictions relying upon this extrapolated high temperature data, INL obtained data using laser-flash thermal diffusivity techniques for two metals used in LWR vessels: SA 533 Grade B, Class 1 (SA533B1) low alloy steel, which is used to fabricate most US LWR reactor vessels; and Type 304 Stainless Steel SS304, which is used in LWR vessel piping, penetration tubes, and internal structures. This paper summarizes the new data, compares it to existing data in the literature, and provides recommended correlations for thermal properties based on this data.

08/01038 Influence of the delayed neutron group parameters on reactivity estimation by rod drop analysis

Geslot, B. *et al. Annals of Nuclear Energy*, 2007, 34, (8), 652–660.
Recent efforts have been undertaken in the reevaluation of the delayed neutron group parameters, namely, the half-life periods and the delayed neutron fractions Indeed, 8-group parameters are now proposed instead of the standard Tuttle 6-group. Moreover, several laboratories among the nuclear engineering community are conducting researches to provide a standard set of group time constants that can suit a lot of fissile isotopes. Since, delayed neutron parameters are widely used in order to estimate reactivity by conducting dynamic experiments, it is worth investigating the influence of the group model (i.e. the number of groups and the number of fitted parameters) on reactivity estimates. This paper focuses on two issues. First, various sets of parameters obtained from JEFF-3.1 precursors data fits are compared. Using simulated rod drop transients, the uncertainty and bias on reactivity estimation is discussed. It is shown that the sets of parameters with fewer fitted parameters and with a greater number of groups give very satisfactory results. Second, the influence of the neutron spectrum is quantified. Biases up to 14% are obtained. Standard statistical tests are done in order to identify such biases on rod drop reactivity estimates.

08/01039 Infrared thermography inspection methods applied to the target elements of W7-X divertor

Missirlian, M. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1747–1755.

The non-destructive examination method is one of the key issues in developing highly loaded plasma-facing components for a next generation fusion devices such as W7-X and ITER. The most critical step is certainly the fabrication and the examination of the bond between the armour and the heat sink. Two inspection systems based on the infrared thermography methods, namely, the transient thermography and the pulsed thermography, are being developed and have been applied to the pre-series of target elements of the W7-X divertor. Results obtained from qualification experiences performed on target elements with artificial calibrated defects allowed to demonstrate the capability of the two techniques and raised the efficiency of inspection to a level which is appropriate for industrial application.

08/01040 Laminar forced convection and flow characteristics for the multiple plate porous insulation

Lim, T. K. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 918–926.
A numerical study of steady state flow and heat transfer has been conducted for the multiple plate porous insulation used in the reactor pressure vessels of 'Magnox' nuclear power stations. The insulation pack studied, consisting of seven dimpled stainless steel sheets and six plane stainless steel sheets, was of the type installed in the Sizewell A plant. In the reactor application the fluid within the insulation pack is carbon dioxide at 20 bar but in the numerical investigation the insulation performance was examined in air at lower pressures. A three-dimensional computation model with a periodicity condition was used in the numerical investigation. Result was obtained for laminar forced convection with constant wall temperatures. Numerical results are presented to show the flow and thermal fields in a single flow passage. In forced convection it is shown that mid-dimple 'peaking' of the Nusselt number distribution may be related directly to the convective influence of distorted velocity profiles.

08/01041 Molecular dynamics simulation of the pressure–volume–temperature data of xenon for a nuclear fuel

Oh, J.-Y. *et al. Journal of Nuclear Materials*, 2008, 372, (1), 89–93.
The exact equation of state for the fission gas is necessary for the accurate prediction of the fission gas behaviour in a nuclear fuel. However, certain kinds of extrapolating data are used to construct and verify the equations of state for the fission gas because experimental data are very limited at high temperatures and pressures that are encountered in the nuclear fuel. To fill the lack of experimental data for the fission gas, the behaviour of Xe gas atoms was investigated by molecular dynamics simulation assuming an exponential-six potential. The molecular dynamics simulation produced reasonable pressure–volume–temperature data for Xe and the simulation results were compared with existing equations of state for Xe.

08/01042 Plutonium management with thorium-based fuels and inert matrix fuels in thermal reactor systems

Schram, R. P. C. and Klaassen, F.C. *Progress in Nuclear Energy*, 2007, 49, (8), 617–622.
The plutonium that is produced by light water reactors worldwide is currently re-used to a limited extent. In the last century, the expected introduction of fast reactors and the associated need for large amounts of plutonium did not take place. The result is that worldwide a stockpile of excess plutonium has formed, which is the dominant contributor to the radiotoxicity of spent nuclear fuel for storage times from $\sim 10^2$ to 10^5 years. One option to reduce or stabilize the plutonium stockpile is to utilize this plutonium in advanced fuel types, such as thorium-based and inert matrix fuels. Because these fuels do not contain uranium, the plutonium consumption rate is very high. In this paper, the status of the fuel research and some recent developments are given.

08/01043 Simulations of H_2O_2 concentration profiles in the water surrounding spent nuclear fuel

Nielsen, F. *et al. Journal of Nuclear Materials*, 2008, 372, (1), 32–35.
A simple mathematical model describing the hydrogen peroxide concentration profile in water surrounding a spent nuclear fuel pellet as a function of time has been developed. The water volume is divided into smaller elements, and the processes that affect hydrogen peroxide concentration are applied to each volume element. The model includes production of H_2O_2 from α-radiolysis, surface reaction between H_2O_2 and UO_2 and diffusion. Simulations show that the surface concentration of H_2O_2 increases fairly rapidly and approaches the steady-state concentration. The time to reach steady-state is sufficiently short to be neglected compared to the times of interest when simulating spent fuel dissolution under deep repository conditions. Consequently, the steady-state approach can be used to estimate the rate for radiation-induced spent nuclear fuel dissolution.

08/01044 Technological aspects of liquid lithium limiter experiment on FTU tokamak

Vertkov, A. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1627–1633.
A liquid lithium limiter (LLL) with a total area of 170 cm^2 and lithium amount of 80 g based on lithium filled capillary-pore system (CPS) as an advanced plasma facing material has been tested for the first time on the medium size high magnetic field tokamak FTU. The main technological aims of the experiment were to test: the compatibility of lithium CPS in real plasma tokamak conditions; the capacity of CPS to self-regenerate an exposed surface and to confine lithium during normal plasma operations and disruptions; the capability to withstand high heat loads without damage of limiter surface. Lithium CPS advantages, experimental base for the tokamak application, general description of LLL design and preparation method were described. No anomalous phenomenon like 'lithium bloom' has occurred in the plasma and no damage of CPS surface and LLL structure has been observed after 60 discharges with power flux up to 5 MW/m^2, as well as on plasma disruptions. Self-restoring of lithium surface has been confirmed. LLL application as a conditioning element with depositing a lithium film on the walls (litization) has resulted in radiation losses, plasma contamination and D_2 recycling reduction. Perspectives of lithium CPS application for further fusion reactors have been considered.

08/01045 Thermoelectric ceramics for generators

Noudem, J. G. *et al. Journal of the European Ceramic Society*, 2008, 28, (1), 41–48.
The manufacturing of thermoelectric modules from conventional materials is well established and widely commercially available. However, fabrication of modules based on oxide materials has been recently emerging and there exist very few reports on their performance. The oxide nature of the thermoelectric elements and the processing specifications involving very high temperatures make the fabrication a difficult task and different from that of conventional thermoelectric modules. This work describes (i) the fabrication of thermoelectric modules based on oxide bulk and foam materials of $Ca_3Co_4O_9$ and $Ca_{0.95}Sm_{0.05}MnO_3$ and (ii) the metal to ceramic contact preparation. The open porous foam structures of thermoelectric materials make it possible to design efficient thermoelectric modules for waste heat sources involving gaseous and liquid media. The possibility of direct large area physical contact of thermoelectric foam elements with hot media will make them efficient electric power generators. The open porous thermoelectric materials with introduced porosities can be good candidates to confine phonons (lattice vibrations) in order to reduce the thermal conductivity if the pores can be made sufficiently small. The performances of the modules were evaluated and possible factors limiting their theoretical performance are discussed. A parameter representing the quality of the modules termed the manufacturing factor representing the cumulative effect of various factors involved in the fabrication process is introduced and evaluated for the modules and compared to other reported modules.

08/01046 Transmutation of nuclear waste in accelerator-driven systems: fast spectrum

Herrera-Martínez, A. *et al. Annals of Nuclear Energy*, 2007, 34, (7), 564–578.
The elimination of nuclear waste is currently a pressing issue in view of the global energy crisis and increasing radiotoxic waste inventories. One potential and well-researched solution to these issues is to transmute nuclear waste in a thorium-based accelerator-driven system, such as the energy amplifier. To develop this technology a prototype capable of transmuting significant quantities of radioactive waste is needed. The proposed energy amplifier demonstration facility, a lead–bismuth cooled 80 MW_{th} device, is designed to couple all the elements of an accelerator-driven system, producing large fast-neutron fluxes capable of transmuting kilograms of individual isotopes. This paper presents an investigation of the neutronic characterization, safety parameters, dynamic behaviour and transmutation potential of such a device when using the plutonium–uranium fuel proposed. These results are compared with those when using thorium–plutonium fuel, demonstrating the advantages of the latter in terms of waste transmutation.

08/01047 Transmutation of nuclear waste in accelerator-driven systems: thermal spectrum

Herrera-Martínez, A. *et al. Annals of Nuclear Energy*, 2007, 34, (7), 550–563.
The TRIGA accelerator-driven experiment is a milestone in the roadmap towards the demonstration of the transmutation of nuclear waste in accelerator-driven systems (ADSs). It is designed in such a way as to couple the different components of an ADS in a realistic environment by using an existing critical reactor adapted to the experiment's objectives, at significant power levels. This paper summarizes the neutronic characterization of the system, an essential step in the design and licensing process. The feasibility of the experiment is demonstrated, establishing the sub-criticality levels of operation and fuel rod configurations. The analyses of the neutron

distribution in space, energy and time detail the behaviour of a real-power thermal ADS and identify the extent and limitations for the experimental programme. Studies investigating the potential of such a system to transmute transuranics and long-lived fission fragments demonstrate the need to move to fast neutron systems in order to efficiently transmute these major components of nuclear waste.

08/01048 Uncertainty analyses of hot channel calculations – determination of the number of failed fuel rods

Panka, I. and Keresztúri, A. *Progress in Nuclear Energy*, 2007, 49, (7), 534–545.

In safety analyses, the final goal is to investigate the fulfillment of the acceptance criteria and the evaluation is usually based on separate hot channel thermal hydraulic/fuel behaviour calculations using the results of the system (nodal) calculations. In the conservative methodology the envelopes of the statistical distributions of the respective input parameters – partly leading to the most adverse consequences, partly covering the uncertainties of methodological origin – are used simultaneously. In order to get more realistic results of hot channel calculations of reactivity initiated accident and anticipated transient without scram (ATWS) events, a new uncertainty analysis methodology was elaborated by combining the one sided tolerance limits method of Wilks with the response surface method. The paper shows the elaborated hot channel calculation methodology by analysing an ATWS event of a Russian-designed pressurized water reactor (VVER-440) and the results of conservative vs. uncertainty analysis are compared with regard to the number of failed fuel rods, the maximum clad surface temperature and the maximum fuel temperature.

Economics, policy, supplies, forecasts

08/01049 An evaluation of a general venting strategy in a CANDU 6 reactor building

Kim, S.-D. *et al. Annals of Nuclear Energy*, 2007, 34, (8), 661–669.

If the reactor building sprays or local air coolers are not available, depressurization by reactor building venting is considered as a useful mitigation strategy for a severe accident management of the Wolsong plants. As the containment filtered vent system is not established in the Wolsong Units, the reactor building isolation system can be a substitute for reactor building venting. The D_2O vapour recovery system which has a 0.76 m (30 in.) diameter penetration is expected to meet the NRC requirements. To investigate the effectiveness of the Reactor Building Venting Strategy, three kinds of accidents are analysed: a SBO, a Small LOCA and a Large LOCA. The reactor building pressure behaviour was analysed with the ISAAC computer code for four different cases: without venting, 379 kPa(g)/345 kPa(g) (55 psig/50 psig), 345 kPa(g)/276 kPa(g) (50 psig/40 psig) and 345 kPa(g)/207 kPa(g) (50 psig/30 psig) valve open/close pressures. When the reactor building spray or local air coolers can not be operated, a depressurization strategy by using the D_2O vapour recovery system could prevent a reactor building failure and reduce the amount of CsI released to the environment. The present study shows that the operation of valves at a pressure of 379 kPa(g)/345 kPa(g) (55 psig/50 psig) is safe and effective. Based on the current study, the strategy of reactor building venting is involved in severe accident management guidance-5.

08/01050 Considerations in testing of ITER first wall mockups

Tanaka, T. J. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1884–1892.

The international thermonuclear experimental reactor (ITER) will have a first wall (FW) made up of ~1900 panels, each with multiple fingers of beryllium (Be) armor joined to water-cooled CuCrZr that is joined to a water-cooled stainless steel backing. The US will provide three toroidal rings of FW modules and the two-port limiters to be used during startup, and the EU, Japan, Korea, China and Russia will supply other FW modules. These ITER partners will prepare first wall quality (FWQ) mockups, 80 mm wide with three 80 mm long Be tiles, in 2007 for a joining quality assurance test at 0.7 MW/m^2 for 12,000 cycles. Sandia will test the US FWQ mockups as well as those of some ITER partners in its plasma material test facility. This paper reports some of the recent thermal and stress analyses, notes other work to be published elsewhere and offers comments about the nature of the testing and analysis of the FWQ mockups.

08/01051 Cost estimation of the canisters for an HLW repository in Korea

Kim, S. K. *et al. Progress in Nuclear Energy*, 2007, 49, (7), 555–566.

This study provides the estimated costs for the canisters of PWR and CANDU spent fuels based on an industrial engineering method and the account classification method. *Ceteris paribus*, it is found that approximately 13% of the unit manufacturing cost based on an industrial engineering estimation was cheaper than that of the account classification method. The unit manufacturing cost of a PWR canister was estimated to be €163,586 by using an industrial engineering estimation. According to the conceptual Korean reference design, for the PWR, 11,375 canisters and for the CANDU, 2835 canisters will be needed to dispose of the spent fuels of 36,000 tU, so the manufacturing costs of the canisters would be about 32% of the total disposal cost. Hence, the manufacturing cost of the canisters for spent fuels is the most dominant cost driver for the overall disposal costs.

08/01052 French experiences and perspectives on plutonium recycling in the existing power fleet

Bernard, P. *Progress in Nuclear Energy*, 2007, 49, (8), 583–588.

Treatment and recycling has been implemented in France from the very beginning of nuclear energy deployment. With the oil shocks in 1973 and 1979, very large scale industrial deployment of LWRs has then been conducted, with now 58 PWRs producing 80% of the total electricity. Modern large scale treatment and recycling facilities have been constructed in the same period: La Hague treatment facilities and MELOX recycling plant. Important industrial feedback results from operation and optimization of fuel cycle backend facilities, which is summarized in the paper. Then are discussed perspectives with recycling.

08/01053 Fuel cycle strategies and plutonium management in Europe

Haas, D. and Hamilton, D. J. *Progress in Nuclear Energy*, 2007, 49, (8), 574–582.

An overview of current nuclear power generation and fuel cycle strategies in Europe is presented, with an emphasis on options for the management of separated plutonium in the medium to long term. Countries which have opted for reprocessing of spent fuel have had to contend with increasing inventories of separated plutonium. Of the various potential options for utilization or disposition of these stockpiles, only light water reactor mixed-oxide fuel programmes are sufficiently technologically mature to be fully operational in several European countries at present. Such reprocessing-recycling programmes allow for a stabilization of the overall separated plutonium stocks, but not for a significant reduction in the stockpile. Moreover, the quality of recycled plutonium decreases at each potential step of re-irradiation. Therefore, optimized or new ways of managing the plutonium stocks in the medium to long term are required. In the present overview, the most promising options for reactor utilization of plutonium are considered in both near-term future reactor and Generation IV systems.

08/01054 Loss of coolant accident analyses on Tehran research reactor by RELAP5/MOD3.2 code

Hedayat, A. *et al. Progress in Nuclear Energy*, 2007, 49, (7), 511–528.

In this paper, a loss of coolant accident (LOCA) in Tehran research reactor (TRR) is analysed. The following procedure consists of three major parts. First, a RELAP5 nodalization of the core and the most important components of the primarily cooling system are developed and steady state condition is simulated and compared with experimental data to validate the nodalization. Then, two large break points are selected for design basis accident analyses. Finally, two main loss of coolant accidents are simulated and developed to analyse LOCA in TRR. It can be concluded that TRR is safe against the LOCA. And also RELAP5/MOD3.2 code can simulate research reactors at operating conditions well but it seems that this code cannot simulates large transient phases of the research reactors accurately as steady state condition specially in low pressure two phase mixtures (water and air).

08/01055 Performance assessments for the geological storage of carbon dioxide: learning from the radioactive waste disposal experience

Maul, P. R. *et al. International Journal of Greenhouse Gas Control*, 2007, 1, (4), 444–455.

The geological storage of carbon dioxide is currently being considered as a possible technology for reducing emissions to atmosphere. Although there are several operational sites where carbon dioxide is stored in this way, methods for assessing the long-term performance and safety of geological storage are at an early stage of development. In this paper the similarities and differences between this field and the geological disposal of radioactive wastes are considered. Priorities are suggested for the development of performance assessment methods for carbon dioxide storage based on areas where experience from radioactive waste disposal can be usefully applied. These include, *inter alia*, dealing with the various types of uncertainty, using systematic methodologies to ensure an auditable and transparent assessment process, developing whole system models and gaining confidence to model the long-term system evolution by considering information from natural systems. An important area of data shortage remains the potential impacts on humans and ecosystems.

08/01056 Plutonium management and Generation IV systems

Lennox, T. A. *et al. Progress in Nuclear Energy*, 2007, 49, (8), 589–596.

This paper discusses the potential role of Generation IV nuclear energy systems in managing plutonium. It briefly reviews the Generation IV goals and their relevance to plutonium management. Each of the six selected Generation IV systems (very high temperature reactor, gas-cooled fast reactor, sodium-cooled fast reactor, supercritical-water-cooled reactor, lead-cooled fast reactor, molten salt reactor) is briefly discussed. The main characteristics of each system are summarized and the capability for plutonium management indicated. The potential for the management of plutonium using Generation IV systems is briefly reviewed from a complete fuel cycle perspective to illustrate the issues in the context of a fleet of reactor and fuel cycle facilities.

08/01057 The appropriateness of TACOM for a task complexity measure for emergency operating procedures of nuclear power plants – a comparison with OPAS scores

Park, J. and Jung, W. *Annals of Nuclear Energy*, 2007, 34, (8), 670–678.

It is well known that complicated procedures frequently cause human performance-related problems that can result in a serious consequence. Unfortunately a systematic framework to evaluate the complexity of procedures is very rare. For this reason, a measure called TACOM (*Ta*sk *Com*plexity) was suggested that is able to quantify the complexity of tasks stipulated in procedures. In addition, it was observed that there is a significant correlation between averaged task performance time data and estimated TACOM scores. In this study, for an additional verification activity, TACOM scores are compared with operators' performance data that are measured by Operator Performance Assessment System (OPAS). As a result, it is believed that TACOM scores seem to be meaningfully correlated with OPAS scores. Thus, it is reasonable to expect that the result of this study can be regarded as a supplementary evidence for supporting the fact that TACOM measure is applicable for quantifying the complexity of tasks to be done by operators.

08/01058 Transmutation capabilities of the CERN energy amplifier system

Kadi, Y. *Progress in Nuclear Energy*, 2007, 49, (8), 606–616.

Progress in particle accelerator technology makes it possible to use a proton accelerator to produce energy and to destroy nuclear waste efficiently. Energy amplifier (EA) systems consist of a sub-critical fast neutron core driven by a proton accelerator. If well designed, they prevent any possible criticality accidents. It has been proposed to take advantage of this sub-criticality in order to use certain types of fuel with poor neutronic properties (for instance those with very small delayed neutron fractions). In this respect, they are particularly attractive for destroying, through fission, transuranic elements produced by present nuclear reactors. EA's could also transform efficiently and at minimal cost long-lived fission fragments using the concept of adiabatic resonance crossing, an innovative method tested at CERN with the TARC experiment.

06 ELECTRICAL POWER SUPPLY AND UTILIZATION

Scientific, technical

08/01059 Control of a 3-phase 4-leg active power filter under non-ideal mains voltage condition

Ucar, M. and Ozdemir, E. *Electric Power Systems Research*, 2008, 78, (1), 58–73.

In this paper, instantaneous reactive power theory (IRP), also known as *p–q* theory based a new control algorithm is proposed for 3-phase 4-wire and 4-leg shunt active power filter (APF) to suppress harmonic currents, compensate reactive power and neutral line current and balance the load currents under unbalanced non-linear load and non-ideal mains voltage conditions. The APF is composed from 4-leg voltage source inverter (VSI) with a common DC-link capacitor and hysteresis–band PWM current controller. In order to show validity of the proposed control algorithm, compared conventional *p–q* and *p–q–r* theory, four different cases such as ideal and unbalanced and balanced-distorted and unbalanced-distorted mains voltage conditions are considered and then simulated. All simulations are performed by using Matlab-Simulink Power System Blockset. The performance of the 4-leg APF with the proposed control algorithm is found considerably effective and adequate to compensate harmonics, reactive power and neutral current and balance load currents under all non-ideal mains voltage scenarios.

08/01060 Critical load bus voltage control using DVR under system frequency variation

Jindal, A. K. *et al. Electric Power Systems Research*, 2008, 78, (2), 255–263.

The paper discusses the voltage control of a critical load bus using a dynamic voltage restorer (DVR) in a distribution system. The critical load requires a balanced sinusoidal waveform across its terminals preferably at system nominal frequency of 50 Hz. It is assumed that the frequency of the supply voltage can vary and is different from the system nominal frequency. The DVR is operated such that it holds the voltage across the critical load bus terminals constant at system nominal frequency irrespective of the frequency of the source voltage. In case of a frequency mismatch, the total real power requirement of the critical load has to be supplied by the DVR. To compensate for frequency variation, the dc link of the DVR is supplied through an uncontrolled rectifier that provides a path for the real power required by the critical load to flow. A simple frequency estimation technique is discussed which uses a moving average process along with zero-crossing detector. Through detailed analysis and simulation studies using PSCAD/EMTDC it is shown that the voltage is completely controlled across the critical load.

08/01061 Energetic and exergetic performance evaluation of a combined heat and power system with the micro gas turbine (MGTCHP)

Balli, O. and Aras, H. *International Journal of Energy Research*, 2007, 31, (14), 1425–1440.

This study deals with the energetic and exergetic performance assessment of a combined heat and power system with micro gas turbine (MGTCHP). Quantitative energy and exergy balance for each component and the whole MGTCHP system was considered, while energy and exergy consumption within the system were determined. The performance characteristics of this MGTCHP system were evaluated using energy and exergy analyses methods. The energetic and exergetic efficiencies of the MGTCHP system are calculated as 75.99% with 254.55 kW – electrical and 155.40 kW – hot water$_{@363.15\,\mathrm{K}}$) and 35.80% with 123.61 kW (as 99.15 kW – electrical and 24.46 kW – hot water$_{@363.15\,\mathrm{K}}$), respectively. The maximum energy loss and exergy consumption occur at 44.03 kW in the stack gas and 129.61 kW in the combustion chamber, respectively.

08/01062 Third harmonic ground-fault protection system of unit-connected generator with two parallel branches per phase

Zielichowski, M. *Electric Power Systems Research*, 2008, 78, (1), 49–57.

The operating conditions of a ground-fault protection reacting to a difference in third harmonic voltages at the star point and at the output terminals of a unit-connected generator with a dipole stator winding formed by two parallel branches in phase are analysed. The voltage feeding the measuring element of the ground-fault protection in the generator is determined for different ways in which its star point is grounded. The paper, analyse the operating conditions of the above protection systems in the unit-connected generator with two parallel branches in stator windings phase and one pair of poles, on the basis of simulation studies. The simulations were run for real generator of 120 MW equipped with generator breakers with additional capacitances to ground. Realistic values of the breakdown channel in the main isolation of the generator stator windings were taken into account. This resistance was determined in experimental tests conducted in real conditions during arcing ground faults.

08/01063 Three-phase, power quality improvement ac/dc converters

Bhat, A. H. and Agarwal, P. *Electric Power Systems Research*, 2008, 78, (2), 276–289.

The generation of harmonics and reactive power flow in a power system is greatly influenced by the widespread use of power electronic converters in addition to other sources of harmonics and reactive power. The design, development and successful application of single-phase, power quality improvement converters in domestic, commercial and industrial environment has made possible the design and development of three-phase, power quality improvement converters and their widespread use in different applications. This paper deals with a comprehensive review of three-phase, power quality improvement converter configurations, control approaches, performance on supply and load sides in terms of input power factor, THD and well-regulated, reduced-rippled dc output, power rating, cost and selection for specific applications. It also provides state-of-the-art of power quality improvement converter technology to researchers, designers and engineers working on three-phase, switched-mode ac–dc converters.

08/01064 Wavelet network-based classification of transients using dominant frequency signature

Chatterjee, S. *et al. Electric Power Systems Research*, 2008, 78, (1), 21–29.

This paper presents a novel approach of classification of transients resulting from changes in circuit topology in a radial distribution system. The analysed data are obtained from experiments as well as simulated model based on Simulink in Matlab environment. Continuous wavelet transform-based dominant frequency signature (DFS) has been used as the key features for identification of circuit topological changes. Conclusions have been drawn after classification of the transients based on DFS using wavelet network.

Economics, policy, supplies, forecasts

08/01065 A μ-analysis approach to power system stability robustness evaluation

Castellanos, R. B. *et al. Electric Power Systems Research*, 2008, 78, (2), 192–201.

A general approach based on structured singular value (SSV) theory is proposed for the analysis of robust stability of large power systems with parameter variations. SSV theory is utilized to find a structured-based parametric uncertainty description of the system that explicitly address and treat the effect of multiple, interrelated uncertain parameters on system dynamic behaviour. Techniques to handle parametric uncertainties are given and methods to generate linear fractional transformation based uncertainty descriptions for the model and its associated uncertainty are discussed. Attention is focused on the study of uncertainties in the nominal system representation arising from two different sources, namely variations in the system operating conditions and uncertainties in the structure of the power system. The performance robustness of the proposed method is verified through simulation studies on a 6-area, 377-machine practical system. In particular, the developed technique is used to estimate the combined effect of variations in the level of power transfer across a critical system interconnection, and variations in the interconnecting tie-line reactance on the stability of critical inter-area modes. Several case studies are presented in which both conventional eigenanalysis techniques and SSV-theory are used to determine robust stability margins.

08/01066 A cooperative game theory analysis for transmission loss allocation

Lima, D. A. *et al. Electric Power Systems Research*, 2008, 78, (2), 264–275.

This paper presents an analysis and discussion, based on cooperative game theory, for the allocation of the cost of losses to generators and demands in transmission systems. A cooperative game theory model was constructed in which the players were represented by equivalent bilateral exchanges and unique loss allocation solution was sought, the Core. Other solution concepts, such as the Shapley Value, the Bilateral Shapley Value and the Kernel were also explored. The main objective was to illustrate why is not possible to find an optimal solution for allocating the cost of losses to the users of a network. Results and relevant conclusions are presented for a 4-bus system and a 14-bus system.

08/01067 A game theory simulator for assessing the performances of competitive electricity markets

Bompard, E. *et al. Electric Power Systems Research*, 2008, 78, (2), 217–227.

In past years, electricity markets were created all over the world following different basis concepts. Market structure, market rules, demand levels, market concentration and energy sources to produce electricity have a strong influence on market performances. Modifications on these aspects may significantly affect market outcomes. Sensitivity analyses need proper simulation tools. In this paper a medium run electricity market simulator (MREMS) based on game theory is presented. This simulator incorporates two different games, one for the unit commitment of thermal units and one for strategic bidding and hourly market clearing. Either a Forchheimer (one leader) or Bertrand (all player are leaders) or even intermediate model with definable number of leaders can be selected, in dependence on the strategic behaviour of the producers, allowing for the simulation of markets with different levels of concentration. The simulator was applied to analyse producers' behaviour during the first operative year of the Italian power exchange. A comparison between simulation and true market results was carried out in order to test the simulator and validate its simplifying hypotheses. MREMS, yet capable to be used stand-alone, was conceived as the heart of a long-term market simulator (LREMS) allowing the simulation of the long-run evolution of the generation park (investments in new plants, refurbishment and dismission of older ones). LREMS is a hierarchic simulator: a long-term 'outer' game takes yearly investment decisions based on mid-term price projections provided by MREMS. Although this paper is mainly devoted to describe MREMS, one specific section will provide an overview of the 'outer' game implemented by LREMS.

08/01068 Active/reactive bid based dispatch models to be used in electricity markets

Gomes, M. H. R. and Saravia, J. T. *Electric Power Systems Research*, 2008, 78, (1), 106–121.

This paper describes two new active/reactive dispatch models to be used by system operators in order to assign reactive power and to validate the economic schedules prepared by market operators together with the injections related with bilateral contracts. When talking about electricity markets one usually refers to active power markets paying less attention to ancillary services, namely to reactive power/voltage control. This usually leads to a chronological sequence of activities that may lead to inefficiencies because active and reactive powers are coupled given the capability diagram of synchronous generators, the ac power flow equations and the branch thermal limits. In this paper, new models are proposed to remarry active and reactive allocation procedures based on a market approach as a way to ensure operation transparency. The resulting optimization problems are solved by a sequential linear programming, approach that allows one to compute active and reactive nodal marginal prices at its final iteration. The paper includes a case study based on the IEEE 24 bus test system to illustrate the application of the developed models and demonstrate their interest in the scope of restructured power systems.

08/01069 An analysis of capacity and price trajectories for the Ontario electricity market using dynamic Nash equilibrium under uncertainty

Genc, T. S. and Sen, S. *Energy Economics*, 2008, 30, (1), 173–191.

This paper studies investments in the Ontario electricity market, which is currently being restructured. The methodology is based on the concept of S-adapted open-loop Nash equilibrium. The evolution of capital investments and pricing behaviour of suppliers is examined as uncertain electricity demand evolves over time (in Ontario). This study is particularly interesting since the implications of two policies are compared: (i) the current setting in which Ontario power generation (OPG) retains its generation units; (ii) the policy (set up in 2003) that required the divestiture of the largest supplier, OPG, and aimed to increase the number of independent suppliers in Ontario. Focus is mainly on the independent generators like Bruce Nuclear. The tools of stochastic programming are used to compute the S-adapted open-loop Nash equilibrium market outcomes. It is found that in the three-player market total capacity installation and market prices are higher than the ones in the five-player market. That is higher capacity may not necessarily alleviate exercise of market power. The authors also confirm the prediction by the National Energy Board that in a market with five major players, OPG's market share may reduce to a percentage between 35% and 40%.

08/01070 Can generalized distribution factors lead to 'objective' transmission toll allocations? Some lessons from the recent Chilean experience

Galetovic, A. and Palma-Behnke, R. *Energy Economics*, 2008, 30, (2), 249–270.

How to charge for transmission lines in a liberalized electricity market is still a conceptually unresolved issue and the literature offers many methods to determine who 'uses' a given line and how to allocate tolls among users. But there seems to be some agreement that once a given method is chosen, calculating use and toll allocations is a mere technical matter. It is suggested, by contrast, that this belief is not warranted. One power flow identification method is applied – generalized load distribution factors – to allocate transmission tolls among the users of the Chilean transmission system and show that almost any allocation of tolls can be achieved by suitably choosing parameter values. Essentially, the method affords many degrees of freedom to the person responsible for setting the parameters needed to apply it. It is argued that this suggests that setting parameter values is a central feature of transmission regulation. Moreover, the results suggest that an allocation method cannot answer the key unresolved question in the literature: what is the structure of tolls that gives economically adequate expansion incentives.

08/01071 Cost and quality gains from diversification and vertical integration in the electricity industry: a DEA approach

Arocena, P. *Energy Economics*, 2008, 30, (1), 39–58.

This paper analyses the degree of economies of vertical integration, diversification and scale in the electricity industry by means of data envelopment analysis. It is estimated that the impact that alternative forms of unbundling would have on the cost and quality of supply, measured as the number and duration of supply interruptions, in a group of Spanish electric utilities. The authors find evidence of the existence of cost and quality gains from integrating power generation and distribution in the range of 1.1–4.9%, whereas diversifying the source of power generation saves between 1.3 and 4.3% of costs and quality. Finally, the scale efficiency of the largest utilities could be improved by dividing them into smaller units, provided that their current vertical scope and generation-mix are preserved.

08/01072 Detection and classification of power quality disturbances using S-transform and modular neural network

Bhende, C. N. *et al. Electric Power Systems Research*, 2008, 78, (1), 122–128.

This paper presents an S-transform based modular neural network (NN) classifier for recognition of power quality disturbances. The excellent time – frequency resolution characteristics of the S-transform makes it an attractive candidate for the analysis of power quality (PQ) disturbances under noisy condition and has the ability to detect the disturbance correctly. On the other hand, the performance of wavelet transform (WT) degrades while detecting and localizing the disturbances in the presence of noise. Features extracted by using the S-transform are applied to a modular NN for automatic classification of the PQ disturbances that solves a relatively complex problem by decomposing it into simpler subtasks. Modularity of neural network provides better classification, model complexity reduction and better learning capability, etc. Eleven types of PQ disturbances are considered for the classification. The simulation results show that the combination of the S-transform and a modular NN can effectively detect and classify different power quality disturbances.

08/01073 Electricity generation and wind potential assessment at Hurghada, Egypt

Ahmed Shata, A. S. and Hanitsch, R. *Renewable Energy*, 2008, 33, (1), 141–148.

A technical and economic assessment has been made of the generation of electricity using wind turbines at one of the most promising wind sites in Egypt: Hurghada. In this paper, wind data recorded over 23 years for this site was used. The WASP program was used to calculate the values of wind speed frequency for the station, their seasonally values have been estimated and compared with measured data. Weibull parameters and the power law coefficient (n) for all seasons at different heights (10–70 m) has been estimated and used to describe the distribution and behaviour of seasonal wind speed and their frequencies at Hurghada. The monthly and annual values of wind potential at a height of 70 m were obtained by extrapolation of the 10 m data from the results of the previous article using the power law. Also, the monthly plant load factor (PLF) has been estimated, which is used to determine the expected annual energy output of a wind energy conversion system (WECS). Variation of annual capacity factor with rated wind speed for 10 different wind turbines has been studied. The lower the rated speed for the WECS of the same height, the higher will be the capacity factor values. The expected electrical energy cost of kWh produced by the wind turbine (Repower MM82) with a capacity of 2 MW considered for Hurghada station was found to be less than 1.5 €cent/kWh.

08/01074 Estimation of cost-effectiveness of the Finnish electricity distribution utilities

Kopsakangas-Savolainen, M. and Svento, R. *Energy Economics*, 2008, 30, (2), 212–229.

This paper examines the cost-effectiveness of Finnish electricity distribution utilities. The authors estimate several panel data stochastic frontier specifications using both Cobb–Douglas and Translog model specifications. The conventional models are extended in order to model observed heterogeneity explicitly in the cost frontier models. The true fixed effects model has been used as a representative of the models that account for unobserved heterogeneity and extended conventional random effect models have been used in analysing the impact of observed heterogeneity. A comparison between the conventional random effects model and models where heterogeneity component is entered either into the mean or into the variance of the inefficiency term shows that relative efficiency scores diminish when heterogeneity is added to the analysis. The true fixed effects model on the other hand gives clearly smaller inefficiency scores than random effects models. In the paper, it is also shown that the relative inefficiency scores and rankings are not sensitive to the cost function specification. The analysis points out the importance of the efficient use of the existing distribution network. The economies of scale results suggest that firms could reduce their operating costs by using networks more efficiently. According to the results, average size firms which have high load factors are the most efficient ones. All firms have unused capacities so that they can improve cost-effectiveness rather by increasing the average distributed volumes than by mergers.

08/01075 Factors influencing the likelihood of regulatory changes in renewable electricity policies

Agnolucci, P. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 141–161.

The renewable electricity literature has expanded in recent years from the analysis of policies focused on research and development and off-grid deployment to the discussion of policies introduced to facilitate the diffusion of renewable electricity in the mainstream market. This article contributes to the discussion of renewable electricity policies by analysing some of the factors influencing the occurrence of regulatory changes, i.e. the financial sustainability and economic effectiveness of the policies, the allocation of costs and benefits; the coherence of the policies; the size and variety of the coalitions supporting and opposing renewable electricity; and the 'Brussels effect'. The importance of these factors is evaluated in the case of three major markets of renewable electricity: Germany, the Netherlands and Denmark.

08/01076 Incentive regulation of electricity distribution networks: lessons of experience from Britain

Jamasb, T. and Pollitt, M. *Energy Policy*, 2007, 35, (12), 6163–6187.

This paper reviews the recent experience of the UK electricity distribution sector under incentive regulation. The UK has a significant and transparent history in implementing incentive regulation in the period since 1990. The successes of this period is demonstrated in reducing costs, prices, and energy losses while maintaining quality of service. The authors also draw out the lessons for other countries in implementing distribution sector reform. The authors conclude by discussing the place of incentive regulation of networks within the wider reform context, the required legislative framework, the need for appropriate unbundling, the importance of quality of service incentives, the regulatory information requirements, and the role of sector rationalization.

08/01077 Influence of massive heat-pump introduction on the electricity-generation mix and the GHG effect – Belgian case study

Luickx, P. J. *et al. International Journal of Energy Research*, 2008, 32, (1), 57–67.

To evaluate the environmental impact of massive heat-pump introduction on greenhouse gas (GHG) emissions, dynamic simulations of the overall electricity-generation system have been performed for Belgium. The simulations are carried out with Promix, a total that models the overall electricity-generation system. For comparison, three heating devices are considered, namely conventional boilers, heat pumps and electrical resistance heating. The introduction of electric heating at the expense of classic heating increases the demand for electricity and generates a shift of emissions from fossil-fuel heating systems to electrical power plants. The replaced classic fossil-fuel-fired heating represents emissions of about 300 kton. With regard to the heat-pump scenarios, both direct heat-pump heating with a coefficient of performance (COP) of 2.5 and accumulation heat-pump heating with a COP of 5 are investigated. The results of the simulations reveal that the massive introduction of heat-pump heating is favourable to the environment. In Belgium, the largest reductions in GHG emissions occur with heat pumps for direct heating, combined with newly commissioned combined cycle (CC) gas-fired plants or with accumulation heat-pump heating. These scenarios bring about overall GHG emission reductions of approximately 200 kton compared with the reference case with conventional heating for the years 2000 and 2010. The amount of additional electricity-related emissions depends on the considered heating device. In 2010, the scenario with accumulation heat pumps results in an overall decrease of Belgian GHG emissions by 0.15% compared with the reference scenario. The expansion of the electricity-generation system with new CC plant has an important favourable impact on GHGs as well. In most cases, the combination of higher electricity demand and the construction of new gas-fired CC plants will lead to lower overall GHG emission.

08/01078 Long-term price and environmental effects in a liberalised electricity market

Lise, W. and Kruseman, G. *Energy Economics*, 2008, 30, (2), 230–248.

This paper studies the effects of endogenous investment decisions in a liberalized electricity market on prices and the environment in the time horizon 2000–2050. Therefore, a computational, game-theoretic, recursive dynamic model is developed. Simulations with the model indicate that perfect competition leads to lower prices and benefits the environment in the form of lower acid and smog emissions. Continued exercise of market power leads to postponed investments and more diversity in the technology portfolio, while under perfect competition there is an earlier switch to gas-based technologies.

08/01079 Methodology for generating thermal and electric load profiles for designing a cogeneration system

Huamani, M. M. and Orlando, A. F. *Energy and Buildings*, 2007, 39, (9), 1003–1010.

Cogeneration will be always an important concept for energy conversion in the future, since it proposes to optimize the use of the energy resources. In the transformation of conventional systems for operation in the cogeneration mode, there exists the necessity to estimate the electric and thermal load profiles hour by hour, so that the cogeneration system can be optimally designed and thus displace the electric energy that would be used by the conventional systems. This work develops a methodology for estimating the electric and thermal load profiles, hour by hour for each month of the year, from the few normally available data. For the electric profile, annual consumption data of electric energy measured at PUC-Rio, every 15 min in the period of 1 year, has been used to validate this methodology. For the thermal profile, a methodology was developed; it discusses how the input thermal energy can be estimated from values of ambient temperature, internal thermal loads and solar radiation incident on the buildings. As an example of this methodology, a thermal load calculation is detailed for a business building and the results compared to those obtained from an existing methodology. The results obtained with these models, allow more accurate predictions for estimating the electric energy with a generator, over a month period, when its capacity is smaller than the building peak demand. A model was also developed to calculate the contribution of the air conditioning electric energy consumption to the total electric energy load.

08/01080 Minimizing fuel and environmental costs for a variable-load power plant (co-)firing fuel oil and natural gas Part 2. Optimization of load dispatch

Kuprianov, V. I. *et al. Fuel Processing Technology*, 2008, 89, (1), 55–61.

A linear programming-based approach was applied to optimize the power (or load) distribution among 200-MW and 310-MW units of a 1330-MW power plant (co-)firing fuel oil and natural gas. The objective function for the optimization was the total costs, including 'internal' (or fuel) and 'external' (or environmental) costs, for the power plant meeting the current load demand. Both fuel and environmental costs (the latter being associated with NO_x, SO_3, SO_2 and CO_2 emissions) of the units were predicted for different fuel options. The total costs for an individual boiler unit were shown to be quasi-linear with the unit load. Optimal load dispatch over the units was determined using a typical daily load curve of the power plant, for distinct climatic seasons in Thailand. The time-domain savings of the total costs resulted from switching the units from actual to the optimized loads were quantified for this power plant.

08/01081 Modelling and evaluation of cooling capacity of earth–air–pipe systems

Wu, H. *et al. Energy Conversion and Management*, 2007, 48, (5), 1462–1471.

Earth–air–pipe systems can be used to reduce the cooling load of buildings in summer. A transient and implicit model based on numerical heat transfer and computational fluid dynamics was developed to predict the thermal performance and cooling capacity of earth–air–pipe systems. Superposition technology is used in the model, incorporating the natural ground temperature field and the turbulent air flow inside the buried pipe. The model developed is validated against experimental investigations on an experimental set-up in Southern China. Good agreement between simulated results and experimental data is obtained. The model is then implemented on the CFD (Computational Fluid Dynamics platform), PHOENICS, to evaluate the effects of the operating parameters (i.e. the pipe length, radius, depth and air flow rate) on the thermal performance and cooling capacity of earth–air–pipe systems. A daily cooling capacity up to 74.6 kW h can be obtained from an earth–air–pipe system installed in that region.

08/01082 Nuclear fission sustainability with hybrid nuclear cycles

Martínez-Val, J. M. and Piera, M. *Energy Conversion and Management*, 2007, 48, (5), 1480–1490.

An analysis is presented on the main requirements to develop nuclear fission in the context of social, economic and environmental sustainability. This analysis is mainly focused on maximizing the energy actually generated from the potential contents of fissionable natural resources. The role of fertile to fissile breeding is highlighted, as well as the need of attaining a very high safety performance in the reactors and other installations of the fuel cycle. The proposal presented in this paper is to use advanced and evolutionary light water reactors as energy producing reactors and to use subcritical fast assemblies as breeders. The main result would be to increase by two orders of magnitude the percentage of energy effectively exploited from fissionable natural resources while keeping a very high level of safety standards in the full fuel cycle.

08/01083 Optimum energy storage techniques for the improvement of renewable energy sources-based electricity generation economic efficiency

Kaldellis, J. K. and Zafirakis, D. *Energy*, 2007, 32, (12), 2295–2305.

The high wind and solar potential along with the extremely high electricity production cost met in the majority of Greek Aegean islands comprising autonomous electrical networks, imply the urgency for new renewable energy sources (RES) investments. To by-pass the electrical grid stability constraints arising from an extensive RES utilization, the adaptation of an appropriate energy storage system (ESS) is essential. In the present analysis, the cost effect of introducing selected storage technologies in a large variety of autonomous electrical grids so as to ensure higher levels of RES penetration, in particular wind and solar, is examined in detail. A systematic parametrical analysis concerning the effect of the ESSs' main parameters on the economic behaviour of the entire installation is also included. According to the results obtained, a properly sized RES-based electricity generation station in collaboration with the appropriate energy storage equipment is a promising solution for the energy demand problems of numerous autonomous electrical networks existing worldwide, at the same time suggesting a clean energy generation alternative and contributing to the diminution of the important environmental problems resulting from the operation of thermal power stations.

08/01084 Overview of the legislation of DC injection in the network for low voltage small grid-connected PV systems in Spain and other countries

Salas, V. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 575–583.

In recent decades there has been an increasing interest in the use of low voltage small grid-connected photovoltaic (PV) systems, conditioned by new incentives from distinct countries. An essential element in those systems is the inverter, that is, the element which converts, in an efficient way, sinusoidal AC current waveform at its output so that it may be connected and synchronized to the utility network. However, that conversion must meet some minimum quality criteria with respect to the harmonics current, DC injection and power factor. Precisely, this work studies the relation of the PV inverter with limits of DC injection in the network, in the AC side. This has been carried out by means of the compilation referring to DC injection for low voltage small grid-connected PV systems exclusively, as well as the international standards and effective legislation in six countries (the USA, Germany, Japan, Spain, Australia and the United Kingdom), where the grid-connected PV industry has experienced remarkable growth in the last 10 years.

08/01085 Prospects of fuel cell auxiliary power units in the civil markets

Agnolucci, P. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4306–4318.

Auxiliary power units (APUs), i.e. devices designed to provide additional onboard power in vehicles, are believed to be an important entry point for fuel cell (FC) technology into commercial markets. Three technologies are under consideration for this market: solid oxide fuel cells (SOFCs), proton exchange membrane fuel cells (PEMFCs) and direct methanol fuel cells (DMFCs). By using the concept of total addressable, potential and capturable markets, this paper discusses the opportunities and challenges of fuel cell auxiliary power units (FC APUs). A number of conclusions can be drawn. As FC APUs do not offer increased fuel efficiency when meeting electrical demand while the main engine is used for propulsion (as opposed to idling), applications on board transit vehicles such as buses seem limited. Potential markets begin to open up in vehicles that either have a very large electricity demand due to many high-energy onboard functions, such as luxury limousines, or that require electrical power whilst stationary. Examples in the latter category include law enforcement vehicles, recreational vehicles, and most importantly heavy duty trucks. Volume and start-up time seem to be the major technical challenges hindering the market penetration of FC APUs. However, whilst the functional benefits of FC APUs over existing technologies are limited, the former must also be able to compete on a cost basis. The intense activities of APU manufacturers suggest a confidence either in the potential for cost reductions or in the consumers' willingness to pay. Similarly, the involvement of a number of big truck manufacturers casts doubt on the extent to which incumbents are taken by surprise by competence-destroying, disruptive and radical technologies like FC APUs.

08/01086 Ranking and selection of power expansion alternatives for multiple objectives under uncertainty

Heinrich, G. *et al. Energy*, 2007, 32, (12), 2350–2369.

Strategic planning in the electricity supply industry is a complex task due to the multiple and often conflicting objectives of the decision makers, as well as the inherent technical and valuation uncertainties involved. As such, a transparent decision support framework is needed, for guiding information management throughout the decision process, in a way which shapes decision outcomes, and enables confident choices to be made. This paper outlines a methodology for the ranking of power expansion alternatives given multiple objectives and uncertainty, and demonstrates this using the South African electricity supply industry. This methodology uses a value function MCDA approach that is augmented with scenario analysis to yield information relating to both the relative performance and credibility of power expansion alternatives. A portfolio of preferred alternatives is then identified based on performance and confidence criteria. Finally a more detailed analysis of the reduced solution set examines short-term technology investment details alongside attribute performance information, so as to gain insight into the decision problem and relate it back to real life actions.

08/01087 Service quality in the electricity industry: the role of privatization and managerial behavior

Fumagalli, E. *et al. Energy Policy*, 2007, 35, (12), 6212–6224.

This paper analyses the relationship between privatization and service quality in the electricity industry, and tests the hypothesis that managerial behaviour is a significant intervening factor. The sample includes 31 Italian distributors over the period 1998–2004; their quality performance is represented by continuity of supply, an aspect of quality that is both contractible and regulated. Results of the empirical analysis suggest that the transfer of shareholdings to private investors does not lead to quality degradation. The results also suggest that managerial dominance translates into a reduction in supply quality; this effect is likely to be particularly strong for public-sector utilities.

08/01088 Supplier's optimal bidding strategy in electricity pay-as-bid auction: comparison of the Q-learning and a model-based approach

Rahimiyan, M. and Rajabi Mashhadi, H. *Electric Power Systems Research*, 2008, 78, (1), 165–175.

In this paper, the bidding decision making problem in electricity pay-as-bid auction is studied from a supplier's point of view. The bidding problem is a complicated task, because of suppliers' uncertain behaviours and demand fluctuation. In a specific case, in which, the market clearing price (MCP) is considered as a continuous random variable with a known probability distribution function (PDF), an analytic solution is proposed. The suggested solution is generalized to consider the effect of supplier market power due to transmission congestion. As a result, an algebraic equation is developed to compute optimal offering price. The basic assumption in this approach is to take the known probabilistic model for the MCP. The above-mentioned method, called model-based approach, is not more applicable in a realistic situation. In order to overcome the drawback of this method, which needs information about the MCP and its PDF, the supplier learns from past experiences using the Q-learning algorithm to find out the optimal bid price. The simulation results of the model-based and Q-learning methods are compared on a studied system. It is shown that a supplier using the Q-learning algorithm is able to find the optimal bidding strategy similar to one obtained by the model-based approach. Furthermore, to analyse a more realistic situation, the suppliers' behaviours are modelled using a multi-agent system. Simulation results illustrate that the studied supplier finds the optimal bidding strategy in power market using the Q-learning algorithm.

08/01089 Technical efficiency and impacts of deregulation: an analysis of three functions in U.S. electric power utilities during the period from 1992 through 2000

Goto, M. and Tsutsui, M. *Energy Economics*, 2008, 30, (1), 15–38.

The main purpose of this study is to examine the impacts of deregulation on technical efficiency and its changes over time for large-scale US electric power utilities during the period from 1992 through 2000. The efficiency of three individual functions are analysed, i.e. generation, transmission/distribution, and general administration, and the deregulatory impacts on each of them. In order to implement the analysis, an input distance function is estimated by using a stochastic frontier analysis. The results indicate that there is a significant impact of deregulation on efficiency in the generation and general administration functions, while no effects are observed in the transmission/distribution function.

08/01090 The established mega watt linear programming-based optimal power flow model applied to the real power 56-bus system in eastern province of Saudi Arabia

Al-Muhawesh, T. A. and Qamber, I. S. *Energy*, 2008, 33, (1), 12–21.

A current trend in electric power industries is the deregulation around the world. One of the questions arise during any deregulation process is: where will be the future generation expansion? In the present paper, the study is concentrated on the wheeling computational method as a part of mega watt (MW) linear programming-based optimal power flow (LP-based OPF) method. To observe the effects of power wheeling on the power system operations, the paper uses linear interactive and discrete optimizer optimizer software as a powerful tool for solving linear programming problems to evaluate the influence of the power wheeling. As well, the paper uses the optimization tool to solve the economic generation dispatch and transmission management problems. The transmission line flow was taken in consideration with some constraints discussed in this paper. The complete linear model of the MW LP-based OPF, which is used to know the future generation potential areas in any utility is proposed. The paper also explains the available economic load dispatch as the basic optimization tool to dispatch the power system. It can be concluded in the present study that accuracy is expensive in terms of money and time and in the competitive market enough accuracy is needed without paying much.

08/01091 The restoration of an electric power system: international survey and discussion of possible innovative enhancements for the Italian system

Barsali, S. *et al. Electric Power Systems Research*, 2008, 78, (2), 239–247.

The present paper reports the main results of a comprehensive international survey that, on behalf of the Italian independent system operator (ISO), the authors have carried out into the main strategies, critical issues and practical experiences related to the restoration plans of a wide set of deregulated systems worldwide. For many ISOs, people directly involved in designing, testing and updating restoration plans have been contacted and interviewed, in order to focus general issues and to outline common improvement trends. Taking the international survey as a starting point, the paper also proposes and discusses possible innovative enhancements being studied for the Italian system, aimed at increasing the effectiveness of the restoration service.

07 STEAM RAISING

Boiler operation/design

08/01092 Efficient design of feedwater heaters network in steam power plants using pinch technology and exergy analysis

Farhad, S. *et al. International Journal of Energy Research*, 2008, 32, (1), 1–11.

A design method is presented based on pinch technology and exergy analysis to reduce heat transfer irreversibility of the feedwater heaters network in steam power plants. In order to show the effects of this method, an extensive study was performed on four steam power plants. The results show that applying this method can decrease the fuel consumption and the condenser load. It also increases the boiler, the feedwater heaters network, and the turbine exergetic efficiencies. On the whole, the results show that applying this method, with a target pinch temperature of 3°C, increases the cycle second law efficiency 0.3–1.3% and the fossil fuel consumption decreases about 64×10^6 kg annually for 8000 operating hours per year of the studied steam power plants.

08/01093 Experimental study of turbulent jet induced by steam jet condensation through a hole in a water tank

Kim, Y.-S. and Youn, Y.-Y. *International Communications in Heat and Mass Transfer*, 2008, 35, (1), 21–29.

A turbulent jet induced by steam jet condensation in a water pool was investigated experimentally. An experimental apparatus equipped with a steam boiler, a single-hole steam sparger, and a water pool, etc. was used. For the measurements, a pitot tube and thermocouples were used for turbulent flow velocity and temperatures, respectively. Overall flow shapes of the turbulent jet by the steam jet condensation are similar to those of axially symmetric turbulent jet flows. The angular coefficients of turbulent rays are quantitatively comparable between the traditional turbulent jet flows and the turbulent jet flows induced by the steam jet condensation in this work. Although the turbulent flows were induced by the steam jet condensation, general theory of turbulent jets was found to be applicable to the turbulent flows of this work.

08/01094 Verification and refinement of the one-dimensional analysis code for the integrated steam generators in an SFR

Kim, Y.-S. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (1), 12–20.

The thermal-hydraulic performance analysis code, ISGA (integrated steam generator analyser) for the design of the integrated steam generator concept of double tube bundle steam generator (DTBSG), which is considered to eliminate a SWR possibility fundamentally in a sodium-cooled fast reactor, was developed for three candidate configurations of tube bundles; the integrated double region, integrated single region and radially separated bundle types. To verify the ISGA code and to confirm the viability of the concept, comparisons to experimental data have been carried out. The effects of properties deviation to total heat transfer rate are negligible through the sensitivity studies. General tendency of the temperature profiles seems to be reasonable for integrated type of the DTBSG. The multi-dimensional effects of the helical tube bundle that includes the entrance effect result in slight discrepancy. The calculated heat transfer rate curve shows a good agreement with the experimental data for the three types of DTBSGs. In the integrated type DTBSG, the convection heat transfer is less dominant for the heat transfer mechanism of the medium flow than in the radially separated type DTBSG. The feasibility of the three candidate DTBSG concepts was demonstrated and the validity of the one-dimensional thermal-hydraulic analysis code ISGA was shown with comparisons to experimental data.

08 COMBUSTION

Burners, combustion systems

08/01095 A perspective on the design of high-temperature boiler components

Perrin, I. J. and Fishburn, J. D. *International Journal of Pressure Vessels and Piping*, 2008, 85, (1–2), 14–21.

Boiler pressure parts are designed to formalize codes such as the ASME Boiler and Pressure Vessel Code. These codes employ a ‘design-by-rule’ approach, which is based on a combination of sound structural mechanics and boiler design and operating experience. These codes have served the industry well, but the need for a number of enhancements has been highlighted by the widespread use of creep strength-enhanced steels, the advent of ultrasupercritical boilers constructed from nickel-based alloys, and the cyclic duty required for some plants. The need for these enhancements is discussed to explain their origin and key challenges that must be tackled to provide robust design methods for the future. In particular, the use of reference stress concepts and design-by-analysis are discussed to highlight some practical issues. Weldments are identified as a particular concern because they are often a life-limiting feature, and since existing code rules do not adequately consider the high-temperature creep failure modes that can arise as a function of geometry, loading and material combination. Associated with the behaviour of welds, multiaxial creep rupture is also identified as a topic that requires further study. The discussion illustrates the multidisciplinary nature of design and need for the materials and structural mechanics communities to work together. This should optimize the use of advanced, expensive alloys and reduce component wall thickness, facilitating pressure part manufacture and enhancing operational flexibility without compromising safety.

08/01096 Co-combustion of peach and apricot stone with coal in a bubbling fluidized bed

Atimtay, A. T. and Kaynak, B. *Fuel Processing Technology*, 2008, 89, (2), 183–197.

In this study a bubbling fluidized bed combustor (BFBC) having an inside diameter of 102 mm and a height of 900 mm was used to investigate the co-combustion characteristics of peach and apricot stones produced as a waste from the fruit juice industry with coal. A lignite coal was used for co-combustion. On-line concentrations of O_2, CO, CO_2, SO_2, NO_x and total hydrocarbons (C_mH_n) were measured in the flue gas during combustion experiments. Variations of emissions of various pollutants were studied by changing the operating parameters (excess air ratio, fluidization velocity, and fuel feed rate). Temperature distribution along the bed was measured with thermocouples. For co-combustion of apricot and peach fruit stones with a lignite coal, various ratios of biomass to coal ranging from 0 to 100 wt.% were tested. For the peach stone co-combustion tests, efficiencies are about 98% and for the apricot stone co-combustion tests, efficiencies ranged between 94.7% and 96.9% for 25%, 50% and 75% of apricot stone in the fuel mixture. The results of this study have shown that as the biomass ratio in the fuel mixture increases, the combustion takes place at the upper regions of the main column. This causes higher temperatures in the freeboard than the bed. Also the CO and hydrocarbon (C_mH_n) emissions increase as the biomass percentage increases in the fuel mixture. This causes decrease in the combustion efficiency. These results suggest that peach and apricot stones are potential fuels that can be utilized for clean energy production in small-scale fruit juice industries by using BFBC. The percentage of peach stones or apricot stones in the fuel mixture is suggested to be below 50 wt.% in order to obtain the emission limits of EU. During the design of the BFBC, one has to be careful about the volatile matter (VM) content of the biomass. For the complete combustion of the VM, longer freeboard or secondary air addition should be considered.

08/01097 Co-combustion of textile residues with cardboard and waste wood in a packed bed

Ryu, C. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (2), 450–458.

The combustible fraction of the municipal waste is mostly bio-derived. Energy recovery of the wastes that cannot be economically recycled is a key part of sustainable energy policy and waste management. Textile residues have high energy content. When burned alone in a packed bed system, however, their combustion efficiency is low due to the irregular propagation of the ignition front and the low burning rates. In order to achieve more efficient combustion of textile residues, a series of co-combustion tests were carried out for various mixture compositions and air flow rates in a packed bed combustor. The combustion performance of these materials was evaluated by using quantitative measures such as ignition rate, burning rate and equivalence ratio. Co-combustion of textile residues with cardboard for a textile fraction of up to 30% achieved satisfactorily high burning rate and low unburned carbon content in the bottom ash. The mixture was more resistant to convective cooling by air, which significantly expanded the range of air flow rate for combustion at high burning rates. In co-combustion with a material that has a very low ignition front speed such as waste wood, the propagation of the ignition front was governed by textile residues. Therefore, the co-combustion of textile residues can be better performed with a material having similar ignition front speeds, in which the two materials simultaneously burn at the ignition front.

08/01098 Combinations of synergistic interactions and additive behavior during the co-oxidation of chars from lignite and biomass

Haykiri-Acma, H. and Yaman, S. *Fuel Processing Technology*, 2008, 89, (2), 176–182.

The aim of this study is to investigate the co-combustion behaviour of two different pyrolytic chars. For this purpose, Elbistan lignite and woody shells of hazelnut were pyrolysed in a tube furnace by heating to 900 °C with a heating rate of 40 °C min^{-1} under dynamic nitrogen flow of 400 mL min^{-1} to obtain pyrolytic char. These chars were mixed to obtain blends having the biomass char in the ratios of 5, 10, and 20 wt.%. Non-isothermal DTA and TGA profiles of the chars were obtained from ambient to 900 °C with a heating rate of 40 °C min^{-1} under the static ambient atmosphere. DTA and TGA profiles of the blend chars were interpreted considering the thermal characteristics such as ignition point, burnout at a given temperature, maximum burning rate, the end of combustion etc. Relations between the fraction of the biomass char in the blends and the thermal behaviour of the blends were evaluated according to the synergistic approach. It was found that addition of biomass char led to important variations in some thermal properties which can not be explained by the additive behaviour. However it can be concluded in general that the combinations of synergistic interactions and additive behaviour govern the thermal properties of the blend chars during co-oxidation.

08/01099 Criteria for piloted ignition of combustible solids

Lyon, R. E. *Combustion and Flame*, 2007, 151, (4), 551–559.

The onset of piloted ignition (flash point) of combustible polymers is predicted by a gas phase combustion energy density of 1.9 MJ/m^3 that describes the lower flammability limit of fuel vapour–air mixtures. The mass flux (1 $\text{g/m}^2\text{s}$) and (virtual) heat release rate (24 kW/m^2) of the solid at incipient ignition derived from this observation are in general agreement with experimental data for piloted ignition of plastics. Sustained ignition marks the transition from lower-limit to stoichiometric burning and the critical heat release rate increases proportionally to 66 kW/m. A critical heat release rate, unique among ignition criteria, is independent of material composition because of the implicit coupling between the gas and condensed phase processes.

08/01100 Effect of co-combustion of chicken litter and coal on emissions in a laboratory-scale fluidized bed combustor

Li, S. *et al. Fuel Processing Technology*, 2008, 89, (1), 7–12.

Co-combustion of chicken litter (CL) with coal was performed in a laboratory-scale fluidized bed combustor to investigate the effect of CL combustion on pollutant emissions. The emissions of major gaseous pollutants including CO, SO_2, H_2S and NO and temperature distribution along the combustor were measured during the tests. Effects of CL fraction and secondary air on combustion characteristics were studied. The experimental results show that CL introduction increases CO emissions and reduces the levels of SO_2. The ratio of H_2S/SO_2 increases with increasing fraction of CL. NO emissions either increase or decrease depending on the percentage of CL in the mixed fuels. The temperature in the freeboard region increases with increasing the fraction of CL while the reverse is true for the bed temperature.

08/01101 Effects of major parameters on micro-combustion for thermophotovoltaic energy conversion

Pan, J. F. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 1089–1095.

For a micro-thermophotovoltaic (TPV) energy conversion device, high surface to volume ratio in the micro-combustor provides a great potential to achieve high surface radiation power output per unit energy input. This work investigated experimentally the effects of three major parameters on micro-combustion, namely hydrogen to oxygen mixing ratio, nozzle to combustor diameter ratio, and wall thickness to combustor diameter ratio. The results show that the high average wall temperature can be achieved at slightly oxygen rich mixing ratios. Nozzle to combustor diameter ratio affects both the magnitude and uniformity of wall temperature distribution. The newly designed thin wall combustor which yields a reduction of axial heat conduction loss is able to increase wall temperature more than 150 K. Optimized design of these parameters will have significant impact on the enhancement of radiation heat output in micro-TPV energy conversion.

08/01102 Efficiency and emissions of a new domestic gas burner with a swirling flame

Hou, S.-S. *et al. Energy Conversion and Management*, 2007, 48, (5), 1401–1410.

This experimental investigation is aimed at studying the influence of five significant parameters, namely swirl flow, loading height, primary aeration, gas flow rate (heat input), gas supply pressure and semi-confined combustion flame on thermal efficiency and CO emissions of domestic gas burners. The authors focus particularly on the effects of a swirling flame on the performance of the new swirl flow burner (SB). The results showed that the swirl flow burner (SB) yields higher thermal efficiency and emits only slightly higher CO concentration than those of the conventional radial flow burner. These characteristics are attributed to the significant improvement in heat transfer coefficient at the vessel bottom resulting from the prolonged residence time of the combustion products in the vicinity of the vessel bottom. With the increase of loading height, the CO emission decreases owing to the reduction of quenching by flame impingement on the load. However, at high loading height, the flame and combustion gases are cooled to a greater extent by mixing with ambient air before contacting the loading vessel, and thus, the temperature gradient for heat transfer is decreased, which leads to the decrease of thermal efficiency. As the thermal input increases, the thermal efficiency is reduced and the CO emission increases. With increasing primary aeration, the CO emission is diminished, but the thermal efficiency is almost unaffected. Additionally, the addition of a shield (named semi-confined combustion flame) achieves a great increase in thermal efficiency. The thermal efficiency of the SB with the semi-confined combustion flame yields a markedly higher thermal efficiency, by about 12%, than that of the RB with open flame.

08/01103 Experimental investigation of combustion characteristics in a multi-staging vortex combustor firing rice husk

Eiamsa-ard, S. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (2), 139–148.

The paper described the combustion characteristics in a multi-staging vortex combustor by using rice husk as fuel. Effects of the operating conditions namely: equivalence ratio ($\Sigma = 0.8$, 1.0 and 1.2) and secondary air ratio ($\lambda = 0.0$, 0.15 and 0.25) on combustion characteristics (temperature distribution, fly ash and gas emission) were experimentally studied. In the experiments, the conventional vortex combustor consisted of two straight concentric cylindrical pipes, combustion chamber (outer chamber) and exhaust pipe (inner chamber). The variable size of middle section of the combustor was designed to be adjustable from $1.0D$ (conventional vortex combustor), to $0.75D$ and $0.5D$ as desired. The changes of the middle chamber size lead to multi-staging vortex inside the combustor. In the experiments, the rice husk was fed into the combustor at constant mass flow rate of 0.3 kg/min. Test results revealed that the mean temperature distribution for the multi-staging vortex combustor with middle chamber size of $0.5D$ was higher than those of $0.75D$ and $1.0D$. The experimental results showed the maximum temperature of about 1176 °C in the vortex chamber with the middle chamber of $0.5D$ at equivalence ratio, $\Sigma = 0.8$ and no secondary air injection, $\lambda = 0.0$. Measurements of gas emissions from cyclone collector consisted of $O_2 = 2.5\%$, $CO_2 = 17.3\%$, and CO = 270 ppm, respectively.

08/01104 Interaction of Lewis number and heat loss effects for a laminar premixed flame propagating in a channel

Chakraborty, S. *et al. International Journal of Thermal Sciences*, 2008, 47, (1), 84–92.

A thermo-diffusive model has been used to investigate the interaction of non-unity Lewis number and heat loss for laminar premixed flames propagating in a channel. A coordinate system moving with the flame has been used to immobilize the flame within the computational domain. At Lewis numbers significantly below unity in presence of high heat loss, tip opening near the centreline and dead space near the wall are simultaneously observed, that gives rise to a multicellular flame with ‘funnel-like’ shape. At low Lewis numbers for fluid flow opposing the flame motion, increase in heat loss leads to a transition from inverted ‘mushroom’ to ‘funnel-shaped’ flame. The heat loss has a stronger effect for fluid flows opposing the flame motion than for fluid flows aiding the flame motion. For Lewis numbers above unity, the dependence of reaction rate on Lewis number gets reversed as heat loss increases from zero to a finite value.

08/01105 Measurements of premixed-flame turbulence generation and modification in a Taylor–Couette burner

Arjomand-Kermani, A. M. and Aldredge, R. C. *Experimental Thermal and Fluid Science*, 2007, 32, (1), 85–97.

Turbulent, premixed lean methane–air flames were studied experimentally in a Taylor–Couette burner, extending the previous work of non-reacting turbulent-flow measurements. A laser-Doppler velocimetry system is employed to measure velocity fluctuations in the circumferential direction at the centre of the annulus where mean velocities are nearly zero. Turbulence parameters such as the intensities, approximated integral and micro-time and length scales and one-dimensional frequency spectra are obtained for the flow-field ahead and behind the flame front. The frequency spectra exhibit a $-5/3$ slope reaffirming isotropic characteristics. It is found that there is an increase in intensity, turbulence Reynolds number and energy across a broad range of frequencies behind the flame along with a shift toward larger scales. However, there appears to be a decrease in amplification of the intensities and turbulence Reynolds number with increasing pre-ignition turbulence in the burner (generated by counter-rotation of the cylinder walls). Results suggest that the presence of flame-generated turbulence in the TC burner is sensitive to both pre-ignition turbulence and equivalence ratio.

08/01106 Online simulation model of the slab-reheating process in a pusher-type furnace

Jaklič, A. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 1105–1114.

This paper presents an online simulation model of the slab-reheating process in a pusher-type furnace in Acroni d.o.o. in Slovenia. The simulation model is connected to the information system of a hot-processing plant that provides online measuring and charging data of the furnace. The simulation model considers the exact geometry of the furnace enclosure, including the geometry of the slabs inside the furnace. A view-factor matrix of the furnace enclosure was determined using the Monte Carlo method. The heat exchange between the furnace gas, the furnace wall and the slab’s surface is calculated using a three-temperature model. The heat conduction in the slabs is calculated using the 3D finite-difference method. The model was validated using measurements from trailing thermocouples positioned in the test slabs during the reheating process in the furnace. A graphical user interface was developed to ensure a user-friendly presentation of the simulation-model results.

08/01107 Polymer membrane air separation performance for portable oxygen enriched combustion applications

Coombe, H. S. and Nieh, S. *Energy Conversion and Management*, 2007, 48, (5), 1499–1505.

The topic of air separation is studied for portable power system applications. Air separation is of interest for controlling and optimizing the combustion characteristics in a liquid fuel burner. In particular, polymeric membranes are investigated for their performance in supplying oxygen enriched air to a small burner. The air separation performance of perfluorodioxole polymer membranes is measured, and the relationship between membrane performance and combustion parameters is investigated. The feasibility of using such membranes for burner based power system applications is demonstrated and appears to be promising. The power draw necessary to achieve prescribed flow and performance was measured and found to be relatively low. A dimensionless enrichment number is defined, and a membrane figure of merit is introduced.

08/01108 The effect of fuel composition on flame dynamics

Hendricks, A. G. and Vandsburger, U. *Experimental Thermal and Fluid Science*, 2007, 32, (1), 126–132.

As fuel sources diversify, the gas turbine industry is under increasing pressure to develop fuel-flexible plants, able to use fuels with a variety of compositions from a large range of sources. However, the dynamic characteristics vary considerably with composition, in many cases altering the thermoacoustic stability of the combustor. The flame dynamics, or the response in heat release rate of the flame to acoustic perturbations, of the three major constituents of natural gas: methane, ethane, and propane were compared. The heat release rate is quantified using OH* chemiluminescence and product gas temperature. Gas temperature is measured by tracking the absorption of two high-temperature water lines, via tunable diode laser absorption spectroscopy. The flame dynamics of the three fuels differ significantly. The changes in flame dynamics due to variations in fuel composition have the potential to have a large effect on the thermoacoustic stability of the combustor.

08/01109 Thermal desorption and pyrolysis of oil contaminated drill cuttings by microwave heating

Robinson, J. P. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 27–32.

Oil contaminated drill cuttings were treated in a single mode microwave cavity, and it was found that certain conditions promote pyrolysis of the oil whereas others caused thermal desorption only. This is particularly interesting since most microwave-induced pyrolysis occurs only when microwave-absorbing materials such as activated carbon are added to the process materials, however the drill cuttings used in this study contain just water as the microwave-absorbing phase. It is shown that higher microwave power and electric field strength are the major factors which appear to determine the mechanism of oil removal, although a number of explanations are suggested as to why pyrolysis occurs. These include poor heat and mass transfer inherent in granular materials, and also the potential effects of bound water. This study demonstrates the volumetric heating potential of granular materials and mixed solids, and has potential applications in the pyrolysis of a range of waste materials from contaminated soils to domestic wastes.

08/01110 Thermogravimetric analysis and kinetics of coal/plastic blends during co-pyrolysis in nitrogen atmosphere

Cai, J. *et al. Fuel Processing Technology*, 2008, 89, (1), 21–27.

Investigations into the co-pyrolytic behaviours of different plastics (high density polyethylene, low density polyethylene and polypropylene), low volatile coal and their blends with the addition of the plastic of 5 wt.% have been conducted using a thermogravimetric analyser. The results indicated that plastic was decomposed in the temperature range 438–521 °C, while the thermal degradation temperature of coal was 174–710 °C. The overlapping degradation temperature interval between coal and plastic was favourable for hydrogen transfer from plastic to coal. The difference of weight loss (W) between experimental and theoretical ones, calculated as an algebraic sum of those from each separated component, was 2.0–2.7% at 550–650 °C. These experimental results indicated a synergistic effect during plastic and coal co-pyrolysis at the high temperature region. In addition, a kinetic analysis was performed to fit thermogavimetric data, the estimated kinetic parameters (activation energies and pre-exponential factors) for coal, plastic and their blends, were found to be in the range of 35.7–572.8 kJ/mol and $27–1.7 \times 10^{38}$ min^{-1}, respectively.

08/01111 Trace element emissions from spontaneous combustion of gob piles in coal mines, Shanxi, China

Zhao, Y. *et al. International Journal of Coal Geology*, 2008, 73, (1), 52–62.

The emissions of potentially hazardous trace elements from spontaneous combustion of gob piles from coal mining in Shanxi Province, China, have been studied. More than ninety samples of solid waste from gob piles in Shanxi were collected and the contents of twenty potentially hazardous trace elements (Be, F, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Mo, Cd, Sn, Sb, Hg, Tl, Pb, Th, and U) in these samples were determined. Trace element contents in solid waste samples showed wide ranges. As compared with the upper continental crust, the solid waste samples are significantly enriched in Se (20x) and Tl (12x) and are moderately enriched in F, As, Mo, Sn, Sb, Hg, Th, and U (2–5x). The solid waste samples are depleted in V, Cr, Mn, Co, Ni, Cu, and Zn. The solid waste samples are enriched in F, V, Mn, Cr, Co, Ni, Cu, Zn, Sb, Th, and U as compared with the Shanxi coals. Most trace elements are higher in the clinker than in the unburnt solid waste except F, Sn, and Hg. Trace element abundances are related to the ash content and composition of the samples. The content of F is negatively correlated with the ash content, while Pb is positively correlated with the ash. The concentrations of As, Mn, Zn, and Cd are highly positively correlated with Fe_2O_3 in the solid waste. The As content increases with increasing sulfur content in the solid waste. The trace element emissions are calculated for mass balance. The emission factors of trace elements during the spontaneous combustion of the gobs are determined and the trace element concentrations in the flue gas from the spontaneous combustion of solid waste are calculated. More than a half of F, Se, Hg and Pb are released to the atmosphere during spontaneous combustion. Some trace element concentrations in flue gas are higher than the national emission standards. Thus, gob piles from coal mining pose a serious environmental problem.

Fire safety

08/01112 Smoke leakage through wall openings in a fire

Wu, C.-W. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 29–37.

This study developed a full-scale smoke-barrier system and established a testing procedure to investigate wall openings of various geometric shapes, which may be passageway for cables and pipes and are usually of irregular shapes, for different pressure differences and temperatures. In addition, a simple analytical model was developed to correlate the experiment data. The results showed that the smoke leakage rate was dependent on several factors, including pressure difference, gas temperature, geometric shape and area of opening. The rate of smoke leakage was proportional to the square root of the pressure difference or to the reciprocal of the square root of the upstream gas temperature. An opening of higher perimeter-to-area ratio had higher resistance against smoke flow and thus allowed smaller rate of smoke leakage. Finally, a geometric loss factor was assigned to the tested wall opening to indicate its smoke leakage characteristics. In the study, the capability of the testing device and the application of the testing procedure were verified to be suitable for the fire tests of more complicate objects, such as smoke barriers or doors, in the future.

09 PROCESS HEATING, POWER AND INCINERATION

Energy applications in industry

08/01113 An empirical analysis of energy efficiency in China's iron and steel sector

Wei, Y.-M. *et al. Energy*, 2007, 32, (12), 2262–2270.

Using Malmquist index decomposition, this paper investigates energy efficiency of China's iron and steel sector during the period 1994–2003. Provincial panel data is employed, allowing various energy inputs and product outputs. The energy efficiency improvement is decomposed into two components: technical change (production frontier shifting effect) and technical efficiency change (catching up effect) over time. The empirical results indicate that the energy efficiency in China's iron and steel sector increased by 60% between 1994 and 2003, which is mainly attributable to technical progress rather than technical efficiency improvement. The energy efficiency gaps among provincial iron and steel sectors during this period have widened. However, energy efficiency of iron and steel plants owned by the state has slowly improved in some regions, such as Shanghai, Liaoning, Beijing and Hubei. Nevertheless, technical efficiency in these four regions has decreased considerably. Energy efficiency in China's two largest private-own iron and steel bases (Heibei and Jiangsu) improved significantly.

08/01114 Application of chemical equilibrium for hydrocarbon isomerization analysis

Estrada-Villagrana, A. D. and De La Paz-Zavala, C. *Fuel*, 2007, 86, (9), 1325–1330.

Isomerization is used in refining industry to upgrade gasoline. Since it is an important process, it is desirable to analyse the reactions that take place in the process. In this paper, the isomerization of a mixture of hydrocarbons was modelled by solving the chemical equilibrium of the system. A direct application of the chemical equilibrium solution cannot reproduce experimental results. However, when some of the system reactions are molar extent limited, the solution can reproduce published experimental data.

08/01115 Carbothermal reduction of alumina: thermochemical equilibrium calculations and experimental investigation

Halmann, M. *et al. Energy*, 2007, 32, (12), 2420–2427.

The production of aluminum by the electrolytic Hall–Héroult process suffers from high energy requirements, the release of perfluorocarbons, and vast greenhouse gas emissions. The alternative carbothermic reduction of alumina, while significantly less energy-intensive, is complicated by the formation of aluminum carbide and oxycarbides. In the present work, the formation of Al, as well as Al_2OC, Al_4O_4C, and Al_4C_3 was proven by experiments on mixtures of Al_2O_3 and activated carbon in an Ar atmosphere submitted to heat pulses by an induction furnace. Thermochemical equilibrium calculations indicate that the Al_2O_3-reduction using carbon as reducing agent is favoured in the presence of limited amounts of oxygen. The temperature threshold for the onset of aluminum production is lowered, the formation of Al_4C_3 is decreased, and the yield of aluminum is improved. Significant further enhancement in the carbothermic reduction of Al_2O_3 is predicted by using CH_4 as the reducing agent, again in the presence of limited amounts of oxygen. In this case, an important by-product is syngas, with a H_2/CO molar ratio of about 2, suitable for methanol or Fischer–Tropsch syntheses. Under appropriate temperature and stoichiometry of reactants, the process can be designed to be thermoneutral. Using alumina, methane, and oxygen as reagents, the co-production of aluminum with syngas, to be converted to methanol, predicts fuel savings of about 68% and CO_2 emission avoidance of about 91%, *vis-á-vis* the conventional production of Al by electrolysis and of methanol by steam reforming of CH_4. When using carbon (such as coke or petcoke) as reducing agent, fuel savings of 66% and CO_2 emission avoidance of 15% are predicted. Preliminary evaluation for the proposed process indicates favourable economics, and the required high temperatures process heat is readily attainable using concentrated solar energy.

08/01116 Comparison of parallel- and counter-flow circuiting in an industrial evaporator under frosting conditions

Aljuwayhel, N. F. *et al. International Journal of Refrigeration*, 2007, 30, (8), 1347–1357.

This paper describes a theoretical model of a large-scale, ammonia-fed evaporator coil used in an industrial refrigeration system and operating under low temperature air and refrigerant conditions that are typically encountered in refrigerated storage spaces. The model is used to simulate the performance of counter-flow and parallel-flow circuited evaporator coil designs under frosting conditions. The counter-flow frost model is validated using *in situ* data obtained from a field-installed evaporator coil. The performance of an evaporator in a parallel-flow circuit arrangement is simulated and compared to counter-flow circuiting. The effects of coil circuiting are evaluated in terms of the frost distribution across the evaporator coil and the associated reduction in cooling capacity during operation.

08/01117 Crypto-steady supersonic pressure-exchange: a simple analytical model

Zhang, H. *et al. Applied Energy*, 2008, 85, (1), 26–40.

This paper is motivated by a long-range goal of developing a new class of turbo-machines, where fluid impellers, created through supersonic wave structures, replace mechanical impellers. This paper is an exploratory study to show how effectively supersonic wave structures can fulfil this goal, and to provide some fundamental insight as to the behaviour. A comparison, at a fundamental level, of the spectrum of flow-induction devices from mechanical turbo-machinery to direct flow induction including steady-flow ejectors, wave rotors, and pressure-change devices is explored. While the authors have been studying various flow-induction devices intended to lead to practical solutions, the details of the flow interactions are obscured by the geometries and the complex interactions. This paper attempts to take a step backward and look at the simplest conceivable model that demonstrates the phenomena thought to be the key to a new technology. This model is a crypto-steady supersonic pressure-exchange process occurring behind a supersonic frictionless semi-infinite flat-plate having a pressure differential between both sides of the plate. It is found that very high compressor efficiencies and energy-transfer rates are possible, even with the presence of a supersonic-flow structure. Because of the high efficiencies, the analysis shows that there is potential for the development of a new generation of direct-flow induction devices far simpler and more compact than conventional turbomachinery, yet far more efficient than conventional ejectors and wave rotors. Fundamental information is provided which will facilitate exploiting supersonic pressure-exchanges, in practical crypto-steady flow-induction devices.

08/01118 Energetic analysis of fruit juice processing operations in Nigeria

Waheed, W. A. *et al. Energy*, 2008, 33, (1), 35–45.

Energy and exergy studies were conducted in an orange juice manufacturing industry in Nigeria to determine the energy consumption pattern and methods of energy optimization in the company. An adaptation of the process analysis method of energy accounting was used to evaluate the energy requirement for each of the eight defined unit operations. The types of energy used in the manufacturing of orange juice were electrical, steam and manual with the respective proportions of 18.51%, 80.91% and 0.58% of the total energy. It was estimated that an average energy intensity of 1.12 MJ/kg was required for the manufacturing of orange juice. The most energy intensive operation was identified as the pasteurizer followed by packaging unit with energy intensities of 0.932 and 0.119 MJ/kg, respectively. The exergy analysis revealed that the pasteurizer was responsible for most of the inefficiency (over 90%) followed by packaging (6.60%). It was suggested that the capacity of the pasteurizer be increased to reduce the level of inefficiency of the plant. The suggestion has been limited to equipment modification rather than process alteration, which constitutes additional investment cost and may not be economical from an energy savings perspective.

08/01119 Energy efficiency developments in the Dutch energy-intensive manufacturing industry, 1980–2003

Neelis, M. *et al. Energy Policy*, 2007, 35, (12), 6112–6131.

In this paper, energy efficiency trends were studied in the Dutch manufacturing industry between 1995 and 2003 using indicators based on publicly available physical production and specific energy consumption data. The authors estimated annual primary energy efficiency improvements in this period at 1.3% on average, with the individual sub-sectors ranging between −0.1% and 1.5%. Energy efficiency developments with respect to electricity, fuels/heat and non-energy use have been monitored separately and are shown to differ significantly (for the sum of the sectors studied: 1.9% for electricity, 2.6% for fuels/heat and −0.1% for non-energy use). The results were combined with those from a previous, similar study for 1980–1995 and show that over the full time period, efficiency improvements of 1% per year have been achieved on average. Based on comparison with other sources and a detailed uncertainty analysis, it is concluded that a reliable top-down monitoring framework was developed for studying energy efficiency trends of the manufacturing industry that can also be applied in other countries where similar data are available. It was also shown that substantial differences exist between energy consumption data available from energy statistics and according to the long term agreement monitoring reports, stressing the need for ongoing independent checks of available energy consumption data to avoid problems in future evaluations of energy efficiency policies.

08/01120 Experimental investigation of a 125 kW twin-fire fixed bed gasification pilot plant and comparison to the results of a 2 MW combined heat and power plant (CHP)

Kramreiter, R. *et al. Fuel Processing Technology*, 2008, 89, (1), 90–102.

Fixed bed biomass gasification is a promising technology to produce heat and power from a renewable energy source. A twin-fire fixed bed gasifier based CHP plant was realized in the year 2003 in Wr. Neustadt, Austria. Wood chips are used as fuel, which are dried and sieved before being gasified to a low calorific gas of about 5.8 MJ/Nm^3_{dry}. Before the clean gas is fed into a gas engine a cyclone and a RME (rapemethylester)/H_2O quench system followed by a wet electrostatic precipitator (ESP) is used for gas cleaning. The CHP plant has a fuel power of 2 MW_{th} and an electric output of 550 kW_{el}. As scale up and optimization tool a hot test rig with a capacity of 125 kW_{th} was built. Basic parameters like the type of wood chips, power and air distribution were varied to investigate the effect on gas composition, tar content in the producer gas and carbon content in the ash. Additionally a temperature profile over the height of the 125 kW hot test rig was measured. Furthermore, the results from the hot test rig are discussed and compared with the results from the 2 MW_{th} demonstration plant.

08/01121 Hydrocarbon plant – new source of energy for future

Kalita, D. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 455–471.

The development of alternative sources for energy and chemicals, particularly the use of plant biomass as a renewable source for fuel or chemical feedstocks, has received much recent attention. This paper attempts to review the work carried out by many workers on evaluation of some plant materials as source of energy and chemical feedstocks and the possibilities of producing hydrocarbon and related chemical products, directly or indirectly. Also an exploratory work carried out at Regional Research Laboratory, Jorhat is discussed. Some future directions, which need to be considered to promote development of these petrocrops, are suggested.

08/01122 Incorporated evaporative condenser

Vrachopoulos, M. G. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 823–828.

The incorporated evaporative condenser developed in this work comprises of a system of fins, basin of water condensates, circuit pump and system of drop cloud via spraying. In the whole provision a system of drop collector is also included for the minimization of water escapes now essential for the operation of system. Actually, the present work aims on the development of such a device for the improvement of the performance of the cooling provision by creating dew point conditions and it is possible to be manufactured and adapted in existing air-cooled cooling groups or heat pumps of single or bilateral type, cooling force region for 0.3–3000 kW, as well as in the production of a new product (new type of air-cooled cooling groups or heat pumps, with incorporated the provision of evaporative condenser type). It has been concluded that the incorporated evaporative condenser improves the coefficient of performance of provisions up to 211% since it decreases the temperature difference of the compressor operation. It also maximizes the life duration of the cooling unit and brings energy saving up to 58% because of the necessary temperature difference reduction.

08/01123 Integration of a free-piston Stirling engine and a moving grate incinerator

Hsieh, Y. C. *et al. Renewable Energy*, 2008, 33, (1), 48–54.

The feasibility of recovering the waste heat from a small-scale incinerator (designed by Industrial Technology Research Institute) and generating electric power by a linear free-piston Stirling engine is investigated in this study. A heat-transfer model is used to simulate the integration system of the Stirling engine and the incinerator. In this model, the external irreversibility is modelled by the finite temperature difference and by the actual heat transfer area, while the internal irreversibility is considered by an internal heat leakage. At a fixed source temperature and a fixed sink temperature, the optimal engine performance can be obtained by the method of Lagrange multipliers. From the energy and mass balances for the interesting incinerator with the feeding rate at 16 t/d, there is enough otherwise wasted energy for powering the Stirling engine and generate more than 50 kW of electricity.

08/01124 Optimization of a large scale industrial reactor by genetic algorithms

Rezende, M. C. A. F. *et al. Chemical Engineering Science*, 2008, 63, (2), 330–341.

The present work aims to employ genetic algorithms (GAs) to optimize an industrial chemical process, characterized by being difficult to be optimized by conventional methods. The considered chemical process is the three phase catalytic slurry reactor in which the reaction of the hydrogenation of *o*-cresol producing 2-methyl-cyclohexanol occurs. In order to describe the dynamic behaviour of the multivariable process, a non-linear mathematical model is used. Due to the high dimensionality and non-linearity of the model, a rigorous one, the solution of the optimization problem through conventional algorithms does not always lead to convergence. This fact justifies the use of an evolutionary method, based on the GAs, to deal with this process. In this way, in order to optimize the process, the GA code is coupled with the rigorous model of the reactor. The aim of the optimization through GAs is the searching of the process inputs that maximizes the productivity of 2-methyl-cyclohexanol subject to the environmental constraint of conversion. Many simulations are conducted in order to find the maximization of the objective function without violating the constraint. The results show that the GAs are used successfully in the process optimization. The selection of the most important GA parameters making use of a factorial design approach by fractional factorial design is proposed. A factorial design approach by a central composite design is also proposed in order to determine the best values of the GA parameters that lead to the optimal solution of the optimization problem.

08/01125 Prandtl-number effects on vertical buoyant jets in forced and mixed convection regimes

Ali, A. *et al. Energy Conversion and Management*, 2007, 48, (5), 1435–1449.

In the present paper, the authors propose a detailed numerical study of the influence of Prandtl number on the hydrodynamic and thermal behaviour of a laminar buoyant free jet. Both round and plane nozzle geometry configurations are studied and compared. Variations of properties like viscosity and thermal conductivity with temperature are neglected. For a given fluid, Prandtl number variation with temperature is also neglected. On the other hand, the variation of density with temperature is only taken into account in terms of the gravity force. The influences of buoyancy and condition at the exit of the nozzle are examined for both geometry configurations (round and plane). Two cases are considered for the latter: uniform or parabolic velocity and temperature profiles. The Prandtl number effect on the jet flow characteristics is studied in both convection regimes: forced and mixed. Solution of the incompressible Navier–Stokes equations is accomplished by a finite difference method. For numerical stability of the scheme, discretization of the governing equations is performed on a staggered mesh. The results, which are presented in the form of graphs and compared with those obtained analytically by other authors; show a suitable agreement far from the exit of the nozzle. These authors replace the emission conditions at the exit of the nozzle by considering two constraints of integration: conservation of momentum and energy, which are checked for whatever profile is used. The results demonstrate first that the effect of the emission conditions, of velocity and temperature, are significant in the region close to the jet exit, in which the flow is governed mainly by the inertias forces. This effect is true for all Prandtl numbers and is consistent with results found in other studies. Secondly, the effect of Prandtl number is significant in the plume region in which the jet flow is influenced by buoyant forces.

08/01126 Scaling-out selective hydrogenation reactions: from single capillary reactor to monolith

Natividad, R. *et al. Fuel*, 2007, 86, (9), 1304–1312.

Selectivity and kinetic studies of the Pd-catalysed hydrogenation of 2-butyne-1,4-diol were performed in a single capillary channel, and monoliths consisting of 1256 capillaries and 5026 capillaries in (I) the pressure range 100–300 kPa (II) the temperature range 298–328 K using a 30% v/v 2-propanol/water solvent. All reactors were operated in downflow mode such that the reaction fluid was in Taylor flow. Transport calculations indicated that liquid–solid transport resistances were low (<5%) and energies of activation were found to be in the range 32–34 kJ mol^{-1}. While the reaction was first order in hydrogen concentration, the order with respect to 2-butyne-1,4-diol changed over the concentration range investigated. A model based upon a Langmuir–Hinshelwood mechanism was applied and found to predict reasonably well the experimental reaction rates. High selectivity values towards the 2-butene-1,4-diol were found in both the single- and multiple-capillary reactors, even at 100% conversion of the alkyne.

08/01127 Scaling-up of instantaneous data of complex kinetics

Jiménez-García, G. *et al. Fuel*, 2007, 86, (9), 1278–1281.

Kinetic data related to complex mixtures of reactants and catalysts are necessary to simulate design and rate industrial chemical reactors. In the particular case of fluidized-bed catalytic cracking, the main reaction takes place in riser reactors; whereas laboratory data are obtained in small fixed bed reactors. Even though this important difference in size and hydrodynamics, laboratory reactors are used to estimate, accurately, yield to products and apparent activation energies of the reactions proposed; however estimated frequency factors are very different from the ones observed at industrial reactors. In this work a scaling-up of frequency factors is performed, assuming that activation energies estimated in laboratory are correct. The adjusting effort is minimized because it is necessary to scale-up only one of the reaction rates and the rest of them are fitted proportionally to the first one. A 5-lump kinetic scheme for catalytic cracking of vacuum gas oils is used to test this approach; prediction obtained for industrial yields is very accurate.

08/01128 Staged combustion of rice straw in a fluidized bed

Okasha, F. *Experimental Thermal and Fluid Science*, 2007, 32, (1), 52–59.

Staged combustion of rice straw has been investigated using an atmospheric bubbling fluidized bed combustor. The combustor has a 300 mm ID and a 3300 mm height. Secondary air was introduced in the freeboard at 1500 mm above the primary air distributor. Rice straw was fed as cylindrical pellets of a 12 mm diameter and 10–15 mm lengths. The obtained results indicate that staged combustion appears an effective technique to reduce NO$_x$ emissions, in particular, at higher operating temperatures. Typically, at 850 °C bed temperature, NO$_x$ concentration is reduced by about 50% when 30% of fed air is introduced as secondary air. Staged operation has a slight, non-monotonic effect on SO$_2$ emission. Combustion efficiency improves with increasing secondary air ratio reaching a maximum value that is mainly attributed to a reduction in fixed carbon loss. With further increase in secondary air ratio, combustion efficiency; however, decreases again since entrained fixed carbon and exhausted carbon monoxide tend to increase. The range of secondary air ratio, over which combustion efficiency improves, expands at higher operating temperatures.

08/01129 T/P23, 24, 911 and 92: new grades for advanced coal-fired power plants – properties and experience

Vaillant, J. C. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (1–2), 38–46.

After the development of the well-known T/P91 grade in the early 1980s and the long industrial experiences since the early 1990s, it has been necessary to develop new steels to answer the demand of the powergen industry. New (ultra) supercritical boilers require materials with advanced creep properties to reach severe steam parameters. For the 2.25% Cr family, grades 23 and 24 are now available to be used instead of the previous grade 22 with many technical and economical advantages. For the 9% Cr steels, new grades such as T/P911 and T/P92 have been developed with higher creep properties than T/P91.

08/01130 The choice of organizational form as a non-technical barrier to agro-bioenergy industry development

Altman, I. and Johnson, T. *Biomass and Bioenergy*, 2008, 32, (1), 28–34.

This paper presents arguments for the importance of market organization in the development of agro-bioenergy industries. One organizational theory, transaction cost economics, highlights the proposed perspective and defines organizational problems that can be typical in agro-bioenergy industries. After considering general features of the current US biopower industry, relying on a survey of power plants actively using forestry and food-processing co-products as fuel, two hypothetical examples illustrate the transaction cost perspective and potential problems that can arise. Finally, possible organizational features and organizational forms in the future agro-bioenergy industry, based on crop residue and energy crops in the USA, are presented utilizing transaction cost economics as a foundation. The paper concludes that if organizational issues are not adequately addressed by social scientists, new and mature technologies alike may stay under-developed commercially.

08/01131 The use of iron oxide as oxygen carrier in a chemical-looping reactor

Abad, A. *et al. Fuel*, 2007, 86, (7–8), 1021–1035.

Chemical-looping combustion (CLC) is a method for the combustion of fuel gas with inherent separation of carbon dioxide. This technique involves the use of two interconnected reactors, an air reactor and a fuel reactor. The oxygen demanded in the fuel combustion is supplied by a solid oxygen carrier, which circulates between both reactors. Fuel gas and air are never mixed and pure CO_2 can be obtained from the flue gas exit. This paper presents the results from the use of an iron-based oxygen-carrier in a continuously operating laboratory CLC unit, consisting of two interconnected fluidized beds. Natural gas or syngas was used as fuel, and the thermal power was between 100 and 300 W. Tests were performed at four temperatures: 1073, 1123, 1173 and 1223 K. The prototype was successfully operated for all tests and stable conditions were maintained during the combustion. The same particles were used during 60 h of hot fluidization conditions, whereof 40 h with combustion. The combustion efficiency of syngas was high, about 99% for all experimental conditions. However, in the combustion tests with natural gas, there was unconverted methane in the exit flue gases. Higher temperature and lower fuel flows increase the combustion efficiency, which ranged between 70% and 94% at 1123 K. No signs of agglomeration or mass loss were detected, and the crushing strength of the oxygen carrier particles did not change significantly. Complementary experiments in a batch fluidized bed were made to compare the reactivity of the oxygen carrier particles before and after the 40 h of operation, but the reactivity of the particles was not affected significantly.

08/01132 Thermal degradation of poly(methyl methacrylate) polymers: kinetics and recovery of monomers using a fluidized bed reactor

Kang, B.-S. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 7–13.

Poly(methyl methacrylate) (PMMA) is a versatile transparent thermoplastic that is used in a wide range of fields and applications, such as in the lenses of exterior lights of automobiles, in electronics, in food containers and in artificial marble. When PMMA is subject to thermal degradation conditions, it degrades mainly into its monomer, methyl methacrylate (MMA). In this study, a virgin PMMA copolymer composed of 97.5% methyl methacrylate, 2.5% methyl acrylate and PMMA waste plastics were investigated. Kinetic measurements of the thermal degradation of the virgin copolymer were carried out with a TGA. The Chatterjee–Conrad and Freeman–Caroll models were applied to determine the pyrolysis kinetic parameters. Both models simulated the experimental DTG curves fairly well. In addition, pyrolysis of the virgin copolymer and the PMMA wastes was carried out using a fluidized bed reactor to recover the monomer. The reaction temperatures ranged from 450 to 500 °C. In each case, the rate of oil recovery was over 97%, and the content of the MMA in the oils was up to 98 wt%. The MMA recovered from the experiments can be used as feedstock for the polymerization of PMMA.

08/01133 Thermal performances investigation of a wet cooling tower

Lemouari, M. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 902–909.

This paper presents an experimental investigation of the thermal performances of a forced draft counter flow wet cooling tower filled with an ‘VGA’ (vertical grid apparatus) type packing. The packing is 0.42 m high and consists of four (04) galvanized sheets having a zigzag form, between which are disposed three (03) metallic vertical grids in parallel with a cross sectional test area of $0.0222\,m^2$ ($0.15\,m \times 0.148\,m$). This study investigates the effect of the air and water flow rates on the cooling water range as well as the tower characteristic, for different inlet water temperatures. Two operating regimes were observed during the air water contact, a pellicular regime (PR) and a bubble and dispersion regime (BDR). These two regimes can determine the best way to promote the heat transfer. The BDR regime seems to be more efficient than the pellicular regime, as it enables to cool larger water flow rates. The comparison between the obtained results and those found in the literature for other types of packing indicates that this type possesses very interesting thermal performances.

08/01134 Water: a critical resource in the thermoelectric power industry

Feeley, T. J. *et al. Energy*, 2008, 33, (1), 1–11.

Water availability represents a growing concern for meeting future power generation needs. In the United States, projected population growth rates, energy consumption patterns, and demand from competing water use sectors will increase pressure on power generators to reduce water use. Water availability and use also exhibit strong regional variations, complicating the nature of public policy and technological response. The US Department of Energy’s National Energy Technology Laboratory (NETL) is engaged in a research and development program to reduce freshwater withdrawal (total quantity of water utilized) and consumption (portion of withdrawal not returned to the source) from existing and future thermoelectric power generating facilities. The Innovations for Existing Plants (IEP) Program is currently developing technologies in five categories of water management projects to reduce water use while minimizing the impacts of plant operations on water quality. This paper outlines the freshwater withdrawal and consumption rates for various thermoelectric power generating types and then estimates the potential benefits of IEP program technologies at both the national and regional levels in the year 2030. NETL is working to protect and conserve water resources while leveraging domestic fossil fuel resources, such as coal, to increase national energy security.

10 SPACE HEATING AND COOLING/HEAT PUMPS

08/01135 A new adaptive PI controller and its application in HVAC systems

Bai, J. and Zhang, X. *Energy Conversion and Management*, 2007, 48, (4), 1043–1054.

The paper concerns the development of a new adaptive PI controller for use in heating, ventilating and air conditioning (HVAC) systems. The process of HVAC control can be described as a first order plus dead time model. A kind of arithmetic of recursive least squares with exponential forgetting combined with model matching of a zero frequency method is adopted to estimate the model’s parameters while the system remained in closed loop. Then, a simple tuning formula for a PI controller with robustness based on the estimated parameters was used to adjust the controller’s parameters automatically while under closed loop. To evaluate the effectiveness of the adaptive PI controller, the proposed method was compared with a H_∞ adaptive PI controller. The simulation results show that the new adaptive PI controller has superior performance to that of the H_∞ adaptive PI controller.

08/01136 A numerical simulation of wing walls using computational fluid dynamics

Mak, C. M. *et al. Energy and Buildings*, 2007, 39, (9), 995–1002.

Larger window openings in the walls of a building may provide better natural ventilation. However, it also increases the penetration of direct solar radiation into indoor environment. The use of wing wall, one of the green features, is an alternative to create effective natural ventilation. Givoni conducted experiments in a wind tunnel to study the ventilation performance of wing walls. This paper presents a numerical study of the ventilation performance of wing walls using computational fluid dynamics (CFD). Two-dimensional and three-dimensional simulations are compared with the results of the experiments of Givoni. The results indicate that wing wall can promote natural ventilation by increasing the air change per hour and the mean indoor air speed relative to wind speed at various wind speeds and wind directions. The best performance of wing wall is at the wind angle of around 45°. The study also shows that 3D CFD simulation produces similar trend to the experimental results though there are some discrepancies.

08/01137 A review and comparative study of the investigations on micro heat pipes

Sobhan, C. B. *et al. International Journal of Energy Research*, 2007, 31, (6–7), 664–688.

This paper reviews recent report investigations on micro heat pipes of various geometrical designs, fabrication methods, operational environments and applications, and provides a comparative analysis of the performance of various designs, based on quantitative design parameters and performance indicators. A comprehensive report of the salient features of these investigations has been presented in a tabular form, in order to provide a quick reference of current micro heat pipe research. Both theoretical and experimental investigations have been included in this review, with special attention given to some of the new concepts and proposed designs for micro heat pipes currently under development.

08/01138 A simple dynamic measurement technique for comparing thermal insulation performances of anisotropic building materials

Yesilata, B. and Turgut, P. *Energy and Buildings*, 2007, 39, (9), 1027–1034.

Measuring or estimating thermal properties of anisotropic building materials can be key obtaining the optimum performance for a particular application. The intensive researches on development of new building materials have necessitated *in situ* thermal testing apparatuses in most research laboratories. Only few standardized techniques are available for accurate thermal testing of anisotropic materials, and they are generally expensive. In the present study, common thermal testing methods are reviewed in brief. A simple and inexpensive thermal testing technique is proposed. The measurement is based on analysis of transient data, which is suitable for comparing effective thermal transmittances of both isotropic and anisotropic building materials. Sample measurements with ordinary concrete and rubberized concretes are performed. The effective thermal transmittances of rubberized concretes are found to be considerably lower than that of the ordinary one.

08/01139 Achievable working range for solid all-desiccant air-conditioning systems under specific space comfort requirements

Panaras, G. *et al. Energy and Buildings*, 2007, 39, (9), 1055–1060.

Solid desiccant air-conditioning systems present a promising solution, in terms of performance level and environmental protection, pointing out their potential to be coupled with thermal solar or waste heat energy source. Nevertheless, these systems are characterized by constraints to the load they can satisfy, through the trade-off between the dehumidification cooling capacity and the latent load of the conditioned space. On that level, one has to note that, for steady environmental conditions, the conditioned space does not present unique value of load, but range of load, corresponding to an array of acceptable temperature and (usually relative) humidity values. In this work a methodology is proposed for the definition of the system's achievable working range under specific set of space (comfort) requirements. Through this approach, the systems present greater potential for covering the space requirements, thus presenting more possibilities on a design basis, and more flexible control strategies, as well. The proposed methodology is presented and discussed through the case study of a solar desiccant air-conditioning system coupled to a typical residential building.

08/01140 Adaptive neuro-fuzzy inference systems (ANFIS) application to investigate potential use of natural ventilation in new building designs in Turkey

Ayata, T. *et al. Energy Conversion and Management*, 2007, 48, (5), 1472–1479.

Natural ventilation in living and working places provides both circulation of clear air and a decrease of indoor temperature, especially during hot summer days. In addition to openings, the dimension ratio and position of buildings play a significant role to obtain a uniform indoor air velocity distribution. In this study, the potential use of natural ventilation as a passive cooling system in new building designs in Kayseri, a midsize city in Turkey, was investigated. First, indoor air velocity distributions with respect to changing wind direction and magnitude were simulated by the FLUENT package program, which employs finite element methods. Then, an adaptive neuro-fuzzy inference systems (ANFIS) model was employed to predict indoor average and maximum air velocities using the simulated data by FLUENT. The simulation results suggest that natural ventilation can be used to provide a thermally comfortable indoor environment during the summer season in the study area. Also, the ANFIS model can be proposed for estimation of indoor air velocity values in such studies.

08/01141 Applying mechanical subcooling to ejector refrigeration cycle for improving the coefficient of performance

Yu, J. *et al. Energy Conversion and Management*, 2007, 48, (4), 1193–1199.

This paper describes a new ejector refrigeration system with mechanical subcooling which uses an auxiliary liquid–gas ejector to enhance subcooling for the refrigerant from condenser. The new system can have larger subcooling degree when circulating pump consumes a little more power compared with conventional ejector refrigeration system. Based on the built mathematical model, the performance of the new ejector refrigeration system was discussed and compared with that of a conventional ejector refrigeration system for refrigerant R142b. Theoretical analysing results show that the new system can efficiently improve the coefficient of performance of ejector refrigeration.

08/01142 Effects of shelterbelt trees on reducing heating-energy consumption of office buildings in Scotland

Liu, Y. and Harris, D. J. *Applied Energy*, 2008, 85, (2–3), 115–127.

Many factors influence the energy consumption of buildings, particularly those related to their design and use. Other factors, such as orientation and the nature of the surroundings, also have an influence, but these are often ignored. In this paper, the influence of trees planted as a shelterbelt is considered, using computer simulations to model the varying energy consumption of a building with or without the shelterbelt trees. It is concluded that a reduction of up to 18% in heating energy consumption can be made by planting an optimum shelterbelt of trees in appropriate situations.

08/01143 Effects of wind on the transmission heat loss in duo-pitched insulated roofs: a field study

Janssens, A. and Hens, H. *Energy and Buildings*, 2007, 39, (9), 1047–1054.

This article presents measuring results of the thermal performance of duo-pitched tiled woodframe roof designs. The roofs have been monitored in a test building, exposed to the outside climate. The experiment was part of a programme to study the hygrothermal performance of highly insulated envelope parts *in situ*, in order to investigate whether a good thermal quality ($U = 0.2\,\mathrm{W/(m^2 K)}$) is achievable with current residential construction practices in Belgium. The results show the effect of wind on the thermal performance of duo-pitched roofs. The measured thermal properties of the roof components are compared to the design values, and related to the wind speeds and directions registered near the test building. The established thermal effects are explained using tracer gas tests to show the pattern of wind driven air flow in the roofs.

08/01144 Efficient numerical method for district heating system hydraulics

Stevanovic, V. D. *et al. Energy Conversion and Management*, 2007, 48, (5), 1536–1543.

An efficient method for numerical simulation and analyses of the steady state hydraulics of complex pipeline networks is presented. It is based on the loop model of the network and the method of square roots for solving the system of linear equations. The procedure is presented in the comprehensive mathematical form that could be straightforwardly programmed into a computer code. An application of the method to energy efficiency analyses of a real complex district heating system is demonstrated. The obtained results show a potential for electricity savings in pumps operation. It is shown that the method is considerably more effective than the standard Hardy Cross method still widely used in engineering practice. Because of the ease of implementation and high efficiency, the method presented in this paper is recommended for hydraulic steady state calculations of complex networks.

08/01145 Environmental evaluation of an air-conditioning system supplied by cooling energy from a bore-hole based heat pump system

Heikkilä, K. *Building and Environment*, 2008, 43, (1), 51–61.

An evaluation of the environmental impacts of an air-conditioning system which uses a bore-hole system for heating and cooling is the aim of this case study. To facilitate the evaluation, the bore-hole based air-conditioning system is compared with a reference system that uses a more traditional source of heat (district heating) and cooling energy (refrigeration). Environmental impacts of the system are examined by the life cycle assessment method, including the weighting step. Results show that the bore-hole based system performs better in three of the four impact categories investigated: acidification, eutrofication, and global warming potential with a 100-year horizon. This is mainly due to the fact that it uses less material in the production phase and less operating energy during the user stage. However, in the category of photochemical ozone creation potential, it performs four times worse than the more traditional system. Nevertheless, the overall environmental impact of the bore-hole based system, evaluated by common weighting methods, is better than the more traditional system. The most dominant environmental impact of both systems arises from the operating energy, although the energy use in the building studied is low.

08/01146 Evaluation of conventional and renewable energy sources for space heating in the household sector

Jaber, J. O. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (1), 278–289.

Residential, space and water heating is dependent particularly upon the combustion of fossil fuels, which thereby contribute significantly to air pollution and build-up of carbon dioxide in the atmosphere. In Jordan, residential space heating accounts for about two thirds of the total residential energy consumption; with kerosene being the most popular fuel used, followed by LPG, for heating purposes. This paper is intended to evaluate space heating systems used in Jordan based on a multi-criteria analysis, using two different methods: the fuzzy sets and analytical hierarchy process (AHP). The benefits and costs of each system are considered, and the overall benefit-to-cost ratios are determined. Analyses using both methods showed that heating systems based on renewable energy, i.e. wind and solar energy, are most favourable, followed by traditional stoves burning petroleum products and finally the worst heating system is the electric heater. On percentage basis, the cost-to-benefit ratio of wind-based heating system is 4.3% and 3.9% as obtained by fuzzy sets and by AHP methods, respectively, compared to 28.5% and 18.6% for electric heating devices, under identical operating conditions.

08/01147 Exergy transfer characteristics of forced convective heat transfer through a duct with constant wall temperature

Wu, S.-Y. *et al. Energy*, 2007, 32, (12), 2385–2395.

The exergy transfer characteristics of fluid flow and heat transfer inside a circular duct under fully developed laminar and turbulent forced convection are presented. Temperature is kept constant at the duct wall. The exergy transfer Nusselt number is put forward and the analytical expressions for exergy transfer Nusselt number are obtained as functions of heat transfer Nusselt number, Reynolds number, Prandtl number, etc. The variations of the local and mean convective exergy transfer coefficient, non-dimensional exergy flux, exergy transfer rate, etc. with operating parameters are presented graphically. By reference to a smooth duct and taking air as working fluid, a numerical analysis of the influence of the Reynolds number and non-dimensional cross-sectional position on exergy transfer characteristics has been conducted. The results show that the process parameters and configuration in the fluid flow and heat transfer inside a duct should be properly selected so that the forced convection process could have the best exergy utilization. In addition, the results corresponding to the exergy transfer and energy transfer are compared.

08/01148 Experimental investigation of shell and coiled tube heat exchangers using Wilson plots

Shokouhmand, H. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (1), 84–92.

In this work, an experimental investigation was performed to study the shell and helically coiled tube heat exchangers. Three heat exchangers with different coil pitches and curvature ratios were tested for both parallel-flow and counter-flow configurations. All the required parameters like inlet and outlet temperatures of tube-side and shell-side fluids, flow rate of fluids, etc. were measured using appropriate instruments. Overall heat transfer coefficients of the heat exchangers were calculated using Wilson plots. Heat transfer coefficients of shell and tube sides were evaluated invoking the calculated overall heat transfer coefficients. The inner Nusselt numbers were compared to the values existed in open literature. Though the boundary conditions were different, a reasonable agreement was observed.

08/01149 Experimental performance investigation of a horizontal ground source compression refrigeration machine

Coşkun, S. *et al. International Journal of Energy Research*, 2008, 32, (1), 44–56.

In this paper, the effect of various system parameters on horizontal ground source compression refrigeration machine (CRM) performance is studied experimentally in Bursa, Turkey. A ground heat exchanger (GHE) system connected to CRM in a test room in the air conditioning and refrigeration laboratory of Uludag University has been designed and constructed. This system was tested for space cooling in August and September 2004 and performance tests were performed during this period. Overall, system mainly consists of the GHE (GHE–water circuit) and CRM (CRM–refrigerant circuit). Refrigerant is R134a. Hourly variations of inlet and outlet water temperatures, extracted heat from test room, rejected heat to ground, compression ratio, total power consumption, and coefficient of performance (COP) values for both whole system and only CRM are obtained. Thermal properties of soil are also estimated by using experimental data and theory. Cooling load of test room and rejected heat to ground, and all COP values are also presented. Finally, heat rejection rate to ground with respect to leaving water temperature from GHE is given. The COP of the overall system changes between 2 and 2.5, also CRM COP values are in the range of 3 and 3.86.

08/01150 Experimental studies of a single-effect absorption refrigerator using aqueous lithium–bromide: effect of operating condition to system performance

Aphornratana, S. and Sriveerakul, T. *Experimental Thermal and Fluid Science*, 2007, 32, (2), 658–669.

This paper describes an experimental investigation of a single-effect absorption using aqueous lithium–bromide as working fluid. A 2 kW cooling capacity experimental refrigerator was tested with various operating temperatures. It was found that the solution circulation ratio (SCR) has a strong effect on the system performance. The measured SCR was 2–5 times greater than the theoretical prediction. This was due to the low performance of the absorber. The use of solution heat exchangers could increase the COP by up to 60%.

08/01151 Experimental study and evaluation of latent heat storage in phase change materials wallboards

Lv, S. *et al. Energy and Buildings*, 2007, 39, (10), 1088–1091.

Phase change materials (PCM) can be applied in building envelops to conserve heat energy. Wallboards incorporated with PCM can automatically absorb indoor redundant heat, which can greatly reduce the load of HVAC systems and save electric energy. In experiments, a PCM wallboard room was constructed by attaching PCM wallboards, developed by incorporating about 26% PCM by weight into gypsum wallboards, to the surface of an ordinary wall. The transition temperature and latent heat of these PCM wallboards were tested by differential scanning calorimetry (DSC). The room testing was conducted to determine the latent heat storage of PCM wallboards. Through experiments, it could be proved that DSC can effectively predict the performance of a full-scale installation of PCM wallboards. Compared with an ordinary room, it was found that the PCM wallboard room could greatly reduce the energy cost of HVAC systems and transfer electric power peak load to valley.

08/01152 Experimental study of an auto-controlled automobile air conditioning system with an externally-controlled variable displacement compressor

Qi, Z. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 927–933.

In this paper, an experimental study of an auto-controlled mobile air conditioning (MAC) system with an externally-controlled variable displacement compressor (EVDC) is performed and analysed. A new displacement control method of EVDC is developed concerning about evaporator characteristics and in-car temperature fluctuation, which indicate the quality of the MAC system. Based on occupant's thermal comfort, the wind-tunnel test results show that the MAC system with an EVDC can maintain the deviation of in-car temperature no more than 2 °C compared with the occupants' desired one. This MAC system gives the occupants a good thermal comfort sensation in the rapid changing environment. The comparison shows that the discharge pressure changes of EVDC vary faster than that of the fixed displacement compressor, which reflects the effect of the internal climate changes.

08/01153 Experimental study on ejector refrigeration system powered by low grade heat

Yapici, R. and Yetişen, C. C. *Energy Conversion and Management*, 2007, 48, (5), 1560–1568.

An ejector refrigeration system has been designed and constructed to operate with hot water. Such a refrigeration system, designed for low pressure refrigerants, can be operated using energy sources such as solar energy, geothermal energy and waste heat. In this study, the effects of the main operating parameters on system performance were experimentally investigated using R-11 as the working fluid and keeping constant the position of the primary nozzle end at the inlet plane of the mixing chamber section of the ejector. The experimental study was performed over a range of vapour generator temperatures from about 90 to 102 °C, evaporator temperatures from 0 to 16 °C and condenser pressures from 114 to 143 kPa, and a COP up to 0.25 was obtained. It was seen that if higher cooling capacity and also lower evaporator temperature are desired from the system, the vapour generator temperature should be increased considerably.

08/01154 Experimental study on HFC125 critical heat pump

Zhou, X. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 988–993.

A critical cycle heat pump with HFC125 was studied experimentally. The experimental result indicates that the heat pump with HFC125 can use the general components of the conventional heat pump well. Hot water with wide-range temperature can be conveniently got by the critical heat pump system through water flow control. The COP_h of the critical cycle drops a little when the temperature of outlet water rises from 60 to 75 °C. And adding heat recovering exchanger cannot improve the performance of the cycle, but can reduce the working pressure of the cycle. Comparing with the CO_2 trans-critical heat pump, HFC125 critical heat pump has a better performance of refrigeration, lower working pressure, which is especially suitable for dual-function of supplying hot water and refrigeration in the civil and industrial buildings.

08/01155 Facade design optimization for naturally ventilated residential buildings in Singapore

Wang, L. *et al. Energy and Buildings*, 2007, 39, (8), 954–961.

Parametric studies of facade designs for naturally ventilated residential buildings in Singapore were carried out to optimize facade designs for better indoor thermal comfort and energy saving. Two criteria regarding indoor thermal comfort for naturally ventilated residential buildings are used in this study. To avoid the perception of thermal asymmetry, temperature difference between mean radiant temperature and indoor ambient air temperature should be less than 2 °C. Thermal comfort regression model for naturally ventilated residential buildings in Singapore was used to evaluate various facade designs either. Facade design parameters: *U*-values, orientations, WWR (window-to-wall ratio) and shading device lengths are considered in the investigation. The building simulation results for a typical residential building in Singapore indicated that the *U*-value of facade materials for north and south orientations should be less than $2.5\,W/m^2\,K$ and the *U*-value of facade materials for north and south orientations should be less than $2\,W/m^2\,K$. From the coupled simulation results, it was found that the optimum window to wall ratio is equal to 0.24. Optimum facade designs and thermal comfort indexes are summarized for naturally ventilated residential buildings in Singapore.

08/01156 Generalized irreversible heat-engine experiencing a complex heat-transfer law

Chen, L. *et al. Applied Energy*, 2008, 85, (1), 52–60.

The fundamental optimal relation between optimal power-output and efficiency of a generalized irreversible Carnot heat-engine is derived based on a generalized heat-transfer law, including a generalized convective heat-transfer law and a generalized radiative heat-transfer law, $q \propto (\Delta T^n)^m$. The generalized irreversible Carnot-engine model incorporates several internal and external irreversibilities, such as heat resistance, bypass heat-leak, friction, turbulence and other undesirable irreversibility factors. The added irreversibilities, besides heat resistance, are characterized by a constant parameter and a constant coefficient. The effects of heat-transfer laws and various loss terms are analysed. The results obtained corroborate those in the literature.

08/01157 Ground-source heat pumps systems and applications

Omer, A. M. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 344–371.

Ground-source or geothermal heat pumps are a highly efficient, renewable energy technology for space heating and cooling. This technology relies on the fact that, at depth, the Earth has a relatively constant temperature, warmer than the air in winter and cooler than the air in summer. A geothermal heat pump can transfer heat stored in the Earth into a building during the winter, and transfer heat out of the building during the summer. Special geologic conditions, such as hot springs, are not needed for successful application of geothermal heat pumps. Ground-source heat pumps (GSHPs) are receiving increasing interest because of their potential to reduce primary energy consumption and thus reduce emissions of greenhouse gases. The technology is well established in North America and parts of Europe, but is at the demonstration stage in the UK. This article provides a detailed literature-based review of ground-source heat pump technology, concentrating on loops, ground systems, and looks more briefly at applications and costs and benefits. It concludes with the prospects for GSHP in the UK. It is concluded that, despite potential environmental problems, geothermal heat pumps pose little if any serious environmental risk when best management practices are applied during the installation, operation, and decommissioning of these systems.

08/01158 Heat transfer and pressure drop correlations for the multi-louvered fin compact heat exchangers

Dong, J. *et al. Energy Conversion and Management*, 2007, 48, (5), 1506–1515.

Experimental studies on the air side heat transfer and pressure drop characteristics for 20 types of multi-louvred fin and flat tube heat exchangers were performed. A series of tests were conducted for air Reynolds numbers of 200–2500 based on the louvre pitch with different fin pitch, fin height, fin thickness, fin louvre angle and flow length at a constant tube side flow rate of $2.8\,m^3/h$. The air side thermal performance data were analysed using the effectiveness-NTU method. Characteristics of the heat transfer and pressure drop for the different geometry parameters were reported in terms of Colburn *j*-factor and Fanning friction *f*-factor as a function of ReL_p. The general correlations for the *j* and *f* factors were derived by regression analysis and F test of significance. The correlations of the *j* and *f* factors predict the test data within a rms error of ±10% and ±12%, and the mean deviations are 4.1% and 5.6%, respectively. In addition, two comparison methods were adopted to evaluate the air side thermal hydraulic performance of the multi-louvred fins.

08/01159 Heat transfer characteristics and pressure drop in channel with V corrugated upper and lower plates

Naphon, P. *Energy Conversion and Management*, 2007, 48, (5), 1516–1524.

The heat transfer characteristics and pressure drop in the channel with V corrugated upper and lower plates under constant heat flux are presented. The test section is the channel with two opposite corrugated plates on which all configuration peaks lie in a staggered arrangement. Corrugated plates with three different corrugated tile angles of 20°, 40° and 60° are tested. The experiments are performed for Reynolds number and heat flux in the ranges of 2000–9000 and $0.5–1.2\,kW/m^2$, respectively. The effects of the different geometrical parameters of the corrugated structure and heat flux on the heat transfer characteristics and pressure drop are discussed. A turbulent mathematical model is employed to determine the temperature and velocity distributions. The corrugated surface has a significant effect on the enhancement of heat transfer and pressure drop. Because of the presence of recirculation zones, the heat transfer coefficients obtained from the channel with the corrugated surface are higher than those with the plain surface. However, the pressure drop also increases.

08/01160 Heat-and-mass transfers modelled for rotary desiccant dehumidifiers

Stabat, P. and Marchio, D. *Applied Energy*, 2008, 85, (2–3), 128–142.

A desiccant-wheel behavioural model has been developed. This model fulfils several criteria, such as simplicity of parameterization; accuracy; ability to characterize the equipment behaviour under all operation conditions; and short computation time. The method of characteristics has been applied to the heat-and-mass transfer partial-differential equations. This transformation provides equations which are similar to those of a rotary heat-exchanger. Then, the model is described by the effectiveness-NTU method and identified from only one nominal-rating point. The model predictions have been compared with experimental and manufacturers' data for a broad range of operating conditions. Good agreement has been found.

08/01161 Heating load vs. COP characteristic of an endoreversible Carnot heat-pump subjected to the heat-transfer law $q \propto (\Delta T^n)^m$

Li, J. *et al. Applied Energy*, 2008, 85, (2–3), 96–100.

The relation between heating load and coefficient of performance of an endoreversible Carnot heat-pump is derived based on a new generalized convective heat-transfer law and generalized radiative heat-transfer law, $q \propto (\Delta T^n)^m$. The results include those obtained in many literature studies and can provide some theoretical guidance for the designs of real heat pumps.

08/01162 HFC-410A vaporisation inside a commercial brazed plate heat exchanger

Longo, G. A. and Gasparella, A. *Experimental Thermal and Fluid Science*, 2007, 32, (1), 107–116.

This paper experimentally investigates HFC-410A vaporization inside a commercial brazed plate heat exchanger: the effects of heat flux, refrigerant mass flux, saturation temperature and outlet conditions are evaluated. The experimental results are reported in terms of refrigerant side heat transfer coefficients and frictional pressure drop. The heat transfer coefficients show great sensitivity to heat flux and outlet conditions and weak sensitivity to saturation temperature. The frictional pressure drop shows a linear dependence on the kinetic energy per unit volume of the refrigerant flow and therefore a quadratic dependence on the refrigerant mass flux. The experimental heat transfer coefficients are compared with two well-known equations for nucleate boiling and a correlation for frictional pressure drop is proposed.

08/01163 Identification and control of multi-evaporator air-conditioning systems

Lin, J.-L. and Yeh, T.-J. *International Journal of Refrigeration*, 2007, 30, (8), 1374–1385.

Modern multi-evaporator air-conditioners (MEACs) incorporate variable-speed compressors and variable-opening expansion valves as the actuators for improving cooling performance and energy efficiency. These actuators have to be properly feedback-controlled; otherwise the systems may exhibit even poorer performance than the conventional machines which use fixed-speed compressors and conventional expansion valves. In this paper, feedback controller design for the MEAC system is first addressed through experimental identification. The identification produces a low-order, linear model suitable for controller design. The feedback controller employed is multi-input–multi-output-based and possesses a cascade structure for dealing with the fast and slow dynamics in the system. To determine appropriate control parameters, conditions that establish the stability for the cascade design are given. Due to the deficiency in control inputs, the proposed control structure exhibits steady-state errors in the superheat responses which in turn can produce unacceptable steady-state superheats. To resolve this issue, the reference superheat settings are determined via an optimization procedure so that the resultant steady-state superheats become acceptable. The control experiments indicate that the proposed controller can successfully regulate the indoor temperatures and maintain the steady-state superheat temperatures at acceptable levels.

08/01164 Influence of lubricant oil on heat transfer performance of refrigerant flow boiling inside small diameter tubes. Part I: experimental study

Wei, W. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 67–76.

Two-phase flow pattern and heat transfer characteristics of refrigerant–oil mixture flow boiling inside small tubes with inside diameters of 6.34 mm and 2.50 mm are investigated experimentally. The test condition of nominal oil concentration is from 0% to 5%, mass flux from 200 to 400 $\text{kg}\,\text{m}^{-2}\,\text{s}^{-1}$, heat flux from 3.2 to 14 $\text{kW}\,\text{m}^{-2}$, evaporation temperature of 5 °C, inlet quality from 0.1 to 0.8, and quality change from 0.1 to 0.2. Wavy, wavy-annular, annular and mist-annular flow pattern in 6.34 mm tube are observed, while only slug-annular and annular flow pattern are observed in 2.50 mm tube. Oil presence can make annular flow to form early and to retard to diminish in quality direction at nominal oil concentration $\geq$3%. Augmentation effect of oil on heat transfer coefficient becomes weakened or even diminishes for small diameter tube while detrimental effect of oil on small tube performance becomes more significant than large tube. For both test tubes, variation of heat transfer coefficient and enhanced factor with oil concentration is irregular. Two-phase heat transfer multiplier with refrigerant–oil mixture properties increases consistently and monotonically with local oil concentration at different vapour quality.

08/01165 Influence of lubricant oil on heat transfer performance of refrigerant flow boiling inside small diameter tubes. Part II: correlations

Wei, W. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 77–84.

The predictive ability of the available state-of-the-art heat transfer correlations of refrigerant–oil mixture is evaluated with the present experiment data of small tubes with inside diameter of 6.34 mm and 2.50 mm. Most of these correlations can be used to predict the heat transfer coefficient of 6.34 mm tube, but none of them can predict heat transfer coefficient of 2.50 mm tube satisfactorily. A new correlation of two-phase heat transfer multiplier with local properties of refrigerant–oil mixture is developed. This correlation approaches the actual physical mechanism of flow boiling heat transfer of refrigerant–oil mixture and can reflect the actual co-existing conditions of refrigerant and lubricant oil. More than 90% of the experiment data of both test tubes have less than ±20% deviation from the prediction values of the new correlations.

08/01166 Investigation on a Stirling refrigerator with thermal buffer tube driven by an oil-lubricated compressor

Wu, Z. *et al. International Journal of Refrigeration*, 2007, 30, (8), 1460–1465.

In this article, a special configuration of a Stirling refrigerator for domestic refrigeration purpose is introduced. A thermal buffer tube is installed between the refrigerator cold-end and the expansion piston to improve the system reliability by moving the expansion piston from low temperature to ambient temperature. Furthermore, a commercial oil-lubricated dual-piston compressor is modified to drive the refrigerator, inside which an elastic membrane is used to transfer acoustic work and separate the working gas of the refrigerator from that of the compressor. Experimental investigations on the refrigerator are performed using helium as the working fluid and a cooling power of 200 W at −78 °C is achieved at 15 Hz working frequency and 2.5 MPa mean pressure. Meanwhile, a rough estimation of the refrigerator COP in terms of cooling power divided by input acoustic power gives the value of 0.64. It gives the possibility of building a low-cost, high efficiency domestic refrigerator.

08/01167 Modelling of a direct evaporative air cooler using artificial neural network

Hosoz, M. *et al. International Journal of Energy Research*, 2008, 32, (1), 83–89.

This paper proposes the use of artificial neural networks (ANNs) to predict various performance parameters of a direct evaporative air cooler. For this arm, an experimental evaporative cooler was operated at steady-state conditions, while varying the dry bulb temperature and relative humidity of the entering air along with the flow rates of air and water streams. Using some of the experimental data for training, a three-layer feed-forward ANN model based on back propagation algorithm was developed. This model was used for predicting various performance parameters of the cooler, namely the dry bulb temperature and relative humidity of the leaving air, mass flow rate of the water evaporated into the air stream, sensible cooling rate, and effectiveness of the cooler. Then, the performance of the ANN predictions was tested by applying a set of new experimental data. The predictions usually agreed well with the experimental values with correlation coefficients in the range of 0.969–0.993, mean relative errors in the range of 0.66–4.04%, and very low root mean square errors. This study reveals that, as an alternative to classical modelling techniques, the ANN approach can be used successfully for predicting the performance of direct evaporative air coolers.

08/01168 Numerical model and experimental validation of heat storage with phase change materials

Bony, J. and Citherlet, S. *Energy and Buildings*, 2007, 39, (10), 1065–1072.

This paper describes the numeric model developed to simulate heat transfer in phase change materials (PCM) plunged in water tank storage. This model, based on the enthalpy approach, takes into account the conduction and the convection into PCM as well as at the interface between PCM and water of the storage. Furthermore, hysterisis and subcooling are also included. This model has been implemented in an existing TRNSYS type of water tank storage. It allows the simulation of a water storage tank filled with PCM modules made of different materials and different shapes such as cylinders, plates or spheres bed. Comparisons between measurements and simulations has been undertake to evaluate the potential of this model.

08/01169 On the green roof system. Selection, state of the art and energy potential investigation of a system installed in an office building in Athens, Greece

Spala, A. *et al. Renewable Energy*, 2008, 33, (1), 173–177.

A detailed and integrated presentation of the green roof systems is provided in the present paper. Aiming to analyse a specific urban case study, the authors describe the basic architectural and scientific principles that characterize its performance and efficiency. Furthermore, a state of the art presentation of the system is provided, including the presentation of several case studies as well as a selection and description of plants that usually are extensively used in the green roof system all over the world. Energy and environmental investigation data of the green roof system performance in an office building located in the greater Athens area are provided. The energy efficiency was examined by calculating the energy savings through an accurate dynamic mathematical model. The thermal performance investigation showed a significant reduction of the building's cooling load during the summer period arriving at approximately 40%. Moreover, the influence of the green roof system in the building's heating load was fount insignificant, and this can be regarded as a great advantage of the system as any interference in the building shell for the reduction of cooling load leads usually to an increase of its heating load.

08/01170 On the thermal and ventilation performance of composite walls

Raymond, J. and Bilgen, E. *Energy and Buildings*, 2007, 39, (9), 1041–1046.

Thermal and ventilation performance is studied in composite walls of traditional wood frame single houses. Equations for heat transfer by conduction, natural convection and radiation are solved using analytical–numerical method. For a standard composite wall, parameters controlling thermal and ventilation performance of composite walls, i.e. the channel width and its surface emissivities are varied and their effect on the overall performance is evaluated. It is found that both the channel width and the emissivity of its surfaces play important roles. There is no optimum width to minimize the heat transfer or to maximize the humidity transport. Compared to standard practice, increased width and employing low emissivity films on channel surfaces may improve thermal performance and humidity evacuation capacity of composite walls.

08/01171 Performance analysis and parametric optimal criteria of an irreversible magnetic Brayton-refrigerator

Xia, Z. *et al. Applied Energy*, 2008, 85, (2–3), 159–170.

An irreversible magnetic Brayton refrigeration-cycle model is established, in which the thermal resistance and irreversibility in the two adiabatic processes are taken into account. Based on the model, the performance characteristics of the magnetic Brayton refrigeration-cycle are investigated and the effects of the irreversibilities and the ratio of the magnetic fields in the two iso-field processes on the performance of the refrigeration cycle are revealed. On the basis of the thermodynamic properties of a paramagnetic material, by using the optimal control-theory, the mathematical expressions for the cooling load and the coefficient of performance are derived and some important performance parameters, e.g. the temperatures of the working substance at several important state-points, are optimized. By means of numerical predictions, the optimal performance characteristic curves of the magnetic Brayton refrigeration-cycle are obtained and analysed. Furthermore, some optimal operating-regions including those for the cooling load, coefficient of performance and the temperatures of the cyclic working substance at the two important state-points are determined and evaluated. Finally, several special cases are discussed in detail.

08/01172 Performance analysis on industrial refrigeration system integrated with encapsulated PCM-based cool thermal energy storage system

Cheralathan, M. *et al. International Journal of Energy Research*, 2007, 31, (14), 1398–1413.

Cool thermal energy storage (CTES) is an advanced energy technology that has recently attracted increasing interest for industrial refrigeration applications such as process cooling, food preservation and building air conditioning systems. An experimental investigation on the performance of an industrial refrigeration system integrated with encapsulated phase change material (PCM)-based CTES system is carried out in the present work. In the experimental set-up a vertical storage tank is integrated with the evaporator of the vapour compression refrigeration system. Effect of the inlet temperature of heat transfer fluid (HTF) on the temperature variation of the PCM and the HTF in the storage tank and the performance parameters namely average rate of charging, energy stored, specific energy consumption (SEC) of the chiller with and without storage system are studied in detail. The effect of porosity variation in the storage tank is also studied. A 1°C decrease in evaporator temperature results in about 3–4% increase in SEC and 1°C decrease in condensing temperature leads to 2.25–3.25% decrease in SEC. The range of HTF inlet temperature and porosity values for optimum performance is reported.

08/01173 Performance evaluation of multi-stage, multi-bed adsorption chiller employing re-heat scheme

Khan, M. Z. I. *et al. Renewable Energy*, 2008, 33, (1), 88–98.

This paper deals with the performance investigation of a silica gel/water-based multi-stage, multi-bed, six-bed adsorption chiller employing re-heat scheme. The innovative chiller is powered by waste heat or renewable energy sources of temperature between 50 and 70 °C along with a coolant of inlet temperature at 30 °C for air-conditioning purpose. The performance of the six-bed adsorption chiller using re-heat scheme is compared with that of the six-bed chiller without re-heat. With the same operating conditions, such as the heat transfer fluid inlet (HTF) temperatures, HTF flow rates, adsorption/desorption cycle time and same chiller physical dimension, it is found that both the cooling capacity and the coefficient of performance of the three-stage chiller with re-heat scheme are superior than those of the three-stage chiller without re-heat scheme.

08/01174 Phase change material-based building architecture for thermal management in residential and commercial establishments

Pasupathy, A. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (1), 36–64.

Efficient and economical technology that can be used to store large amounts of heat or cold in a definite volume is the subject of research for a long time. Thermal storage plays an important role in building energy conservation, which is greatly assisted by the incorporation of latent heat storage (LHS) in building products. LHS in a phase change material (PCM) is very attractive because of its high storage density with small temperature swing. It has been demonstrated that for the development of a latent heat storage system in a building fabric, the choice of the PCM plays an important role in addition to heat transfer mechanism in the PCM. Thermal energy storage in the walls, ceiling and floor of buildings may be enhanced by encapsulating or embedding suitable PCMs within these surfaces. They can either capture solar energy directly or thermal energy through natural convection. Increasing the thermal storage capacity of a building can increase human comfort by decreasing the frequency of internal air temperature swings so that the indoor air temperature is closer to the desired temperature for a longer period of time. This paper aims to gather the information from the earlier works on the developments of PCM's incorporation in building, the problems associated with the selection of PCM and the various methods used to contain them for space heating and cooling applications.

08/01175 Simulation of heat exchanger network (HEN) and planning the optimum cleaning schedule

Sanaye, S. and Niroomand, B. *Energy Conversion and Management*, 2007, 48, (5), 1450–1461.

Modelling and simulation of heat exchanger networks for estimating the amount of fouling, variations in overall heat transfer coefficient, and variations in outlet temperatures of hot and cold streams has a significant effect on production analysis. In this analysis, parameters such as the exchangers' types and arrangements, their heat transfer surface areas, mass flow rates of hot and cold streams, heat transfer coefficients and variations of fouling with time are required input data. The main goal is to find the variations of the outlet temperatures of the hot and cold streams with time to plan the optimum cleaning schedule of heat exchangers that provides the minimum operational cost or maximum amount of savings. In this paper, the simulation of heat exchanger networks is performed by choosing an asymptotic fouling function. Two main parameters in the asymptotic fouling formation model, i.e. the decay time of fouling formation (τ) and the asymptotic fouling resistance (R_f^∞) were obtained from empirical data as input parameters to the simulation relations. These data were extracted from the technical history sheets of the Khorasan Petrochemical Plant to guaranty the consistency between the model outputs and the real operating conditions. The output results of the software program developed, including the variations with time of the outlet temperatures of the hot and cold streams, the heat transfer coefficient and the heat transfer rate in the exchangers, are presented for two case studies. Then, an objective function (operational cost) was defined, and the optimal cleaning schedule of the HEN (heat exchanger network) in the Urea and Ammonia units were found by minimizing the objective function using a numerical search method. Based on this minimization procedure, the decision was made whether a heat exchanger should be cleaned or continue to operate. The final result was the most cost effective plan for the HEN cleaning schedule. The corresponding savings by implementing the optimum cleaning schedules are reported in the paper.

08/01176 System optimization and experimental research on air source heat pump water heater

Zhang, J. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 1029–1035.

This paper deals with the system optimization of air source heat pump water heater (ASHPWH), including calculating and testing. The ASHPWH system consists of a heat pump, a water tank and connecting pipes. Air energy is absorbed at the evaporator and pumped to storage tank via a Rankine cycle. The coil pipe/condenser releases condensing heat of the refrigerant to the water side. An ASHPWH using a rotary compressor heated the water from initial temperature to the set temperature (55 °C). The capillary tube length, the filling quantity of refrigerant, the condenser coil tube length and system matching are discussed accordingly. From the testing results, it could be seen that the system performance COP could be improved obviously.

08/01177 The effect of heat-pipe air-handling coil on energy consumption in central air-conditioning system

Wan, J. W. *et al. Energy and Buildings*, 2007, 39, (9), 1035–1040.

A study was carried out to investigate the effect of heat-pipe air-handling coil on energy consumption in a central air-conditioning system with return air. Taking an office building as an example, the study shows that compared with conventional central air-conditioning system with return air, the heat-pipe air-conditioning system can save cooling and reheating energy. In the usual range of 22–26 °C indoor design temperature and 50% relative humidity, the RES (rate of energy saving) in this office building investigated is 23.5–25.7% for cooling load and 38.1–40.9% for total energy consumption. The RES of the heat-pipe air-conditioning system increases with the increase of indoor design temperature and the decrease of indoor relative humidity. The influence of indoor relative humidity on RES is much greater than the influence of the indoor design temperature. The study indicates that a central air-conditioning system can significantly reduce its energy consumption and improve both the indoor thermal comfort and air quality when a heat-pipe air-handling coil is employed in the air-conditioning process.

08/01178 The impact of gas blockage on the performance of a thermoacoustic refrigerator

Akhavanbazaz, M. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 231–239.

Thermoacoustics deals with the conversion of sound energy into heat and vice versa. Thermoacoustic refrigerator is a device that transfers heat from a cold medium to warm medium by using sound energy as a work input. In this paper, the impact of the gas blockage was investigated for three cases; no heat exchanger, heat exchanger with small thermal contact area and heat exchanger with large thermal contact area. The experiments were conducted in a half-wavelength standing wave resonator. The position of the stack was optimized experimentally and was in good agreement with the theoretical value. The results show that the gas blockage has a significant impact on the thermoacoustic process inside the stack. The temperature difference across the stack decreases with an increase in the gas blockage. The relationship between the gas blockage fraction and the temperature difference across the stack is linear. The impact of heat exchangers on the thermoacoustic process was also studied. The results show that a heat exchanger with larger thermal contact area increases the heat exchange between the heat exchanger fluid and the stack, but reduces the cooling power and increases the work input to the stack due to the increased gas blockage. It is concluded that when thermoacoustic devices are used as a refrigerator, there is a compromise between the cooling power of the device and the heat exchanged with the heat exchangers. Therefore, the optimization of these parameters is necessary in order to optimize the performance of the thermoacoustic refrigerator.

08/01179 Theoretical and experimental research on the working process of screw refrigeration compressor under superfeed condition

Wu, H. *et al. International Journal of Refrigeration*, 2007, 30, (8), 1329–1335.

In order to increase the refrigeration capacity and improve the coefficient of performance (COP), an economizer arrangement is used in the refrigeration system with screw refrigeration compressor. In this system, the mid-pressure refrigerant gas from the economizer is injected in the screw refrigeration compressor. So it affects the performance of the compressor. In this paper, the working process of a twin screw refrigeration compressor with economizer under different superfeed pressures is studied. A mathematical model for simulating the working process of screw refrigeration compressor under superfeed condition with the economizer is presented; especially the flow coefficient of superfeed is obtained by the experimental research. To verify the model, the p–V diagrams (pressure–volume diagrams) of screw refrigeration compressor under different superfeed pressures with the economizer are recorded successfully by making use of a micro-type pressure sensor that embedded into the groove at the root of the female rotor on the discharge side. The p–V diagrams of theoretical calculation are in good agreement with the results of experimental recorded, which lead to conclusion that the model can be used as a powerful tool for performance prediction of screw refrigeration compressor, also, it is very helpful for refrigeration system design.

08/01180 Thermoeconomic analysis of household refrigerators

Hepbasli, A. *International Journal of Energy Research*, 2007, 31, (10), 947–959.

This study deals with thermoeconomic analysis of household refrigerators for providing useful insights into the relations between thermodynamics and economics. In the analysis, the EXCEM method based on the quantities exergy, cost, energy and mass is applied to a household refrigerator using the refrigerant R134a. The performance evaluation of the refrigerator is conducted in terms of exergoeconomic aspects based on the various reference state temperatures ranging from 0 to 20°C. The exergy destructions in each of the components of the overall system are determined for average values of experimentally measured parameters. Exergy efficiencies of the system components are determined to assess their performances and to elucidate potentials for improvement. Thermodynamic loss rate-to-capital cost ratios for each components of the refrigerator are investigated. Correlations are developed to estimate exergy efficiencies and ratios of exergy loss rate-to-capital cost as a function of reference (dead) state temperature. The ratios of exergy loss rates to capital cost values are obtained to vary from 2.949×10^{-4} to $3.486 \times 10^{-4}\,\mathrm{kW\,US\$^{-1}}$. The exergy efficiency values are also found to range from 13.69 to 28.88% and 58.15 to 68.88% on the basis of net rational efficiency and product/fuel at the reference state temperatures considered, respectively. It is expected that the results obtained will be useful to those involved in the development of analysis and design methodologies that integrate thermodynamics and economics.

08/01181 Three-dimensional thermal and airflow (3D-TAF) model of a dome-covered house in Canada

Lin, Y. and Zmeureanu, R. *Renewable Energy*, 2008, 33, (1), 22–34.

A dome-covered house is an example of designing sustainable buildings by learning from the optimized biological forms from the nature. The paper presents a 3-D thermal and air flow model that estimates the energy needs of a dome-covered house. The model is verified with CFD simulations under the COMSOL Multiphysics environment, experimental measurements and simulation results from similar structures published by other researchers. The use of the dome is expected to reduce the annual heating load of the house by 62.6%, compared with that of an isolated house located in Montreal at 45°N latitude.

08/01182 Turbulent flow heat transfer and pressure loss in a double pipe heat exchanger with louvered strip inserts

Eiamsa-ard, S. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (2), 120–129.

In the present work, heat transfer and friction characteristics were experimentally investigated, employing louvred strips inserted in a concentric tube heat exchanger. The louvred strip was inserted into the tube to generate turbulent flow which helped to increase the heat transfer rate of the tube. The flow rate of the tube was in a range of Reynolds number between 6000 and 42,000. The turbulent flow devices were consisted of (1) the louvred strips with forward or backward arrangements, and (2) the louvred strip with various inclined angles ($\theta = 15°$, 25° and 30°), inserted in the inner tube of the heat exchanger. In the experiment, hot water was flowed through the inner tube whereas cold water was flowed in the annulus. The experimental data obtained were compared with those from plain tubes of published data. Experimental results confirmed that the use of louvred strips leads to a higher heat transfer rate over the plain tube. The increases in average Nusselt number and friction loss for the inclined forward louvred strip were 284% and 413% while those for the backward louvred strip were 263% and 233% over the plain tube, respectively. In addition, the use of the louvred strip with backward arrangement leads to better overall enhancement ratio than that with forward arrangement around 9–24%.

08/01183 Two bed silica gel–water adsorption chillers: an effectual lumped parameter model

Wang, X. and Chua, H. T. *International Journal of Refrigeration*, 2007, 30, (8), 1417–1416.

This article develops an improved lump-parameter design model to investigate the water-circulation heat recovery scheme as applied to the two-bed silica gel–water adsorption chillers. This demonstrates that performance predictions stemming from this improved lump-parameter formalism compares favourably with experimental results at various conditions, particularly at the industrial rated conditions. It finds that the present lump-parameter formalism adequately elucidates the water-circulation heat recovery scheme as does the distributed-parameter formalism. In the studied working condition of a two-bed silica gel–water adsorption chiller, the differences in cooling capacities and coefficients of performance (or COP) by using the two different formalisms are typically less than 10%. This gives rise to a useful and rapid design tool for the industry.

08/01184 Uneven gridding of thermal nodal networks in floor heating simulations

Holopainen, R. *et al. Energy and Buildings*, 2007, 39, (10), 1107–1114.

In this paper, the use of an uneven nodal network in floor heating simulation with finite difference heat balance method is examined. Two floor heating test cases, homogenous and multilayer floor, are presented. Temperature distributions on the floor surface and heat flows through the floor surface are simulated with even and uneven gridding approaches. It is shown that the total number of nodes can be reduced by placing the densest gridding in sections where the curvature of the temperature gradient is steepest.

08/01185 Viscosity and thermal conductivity of some refrigerants at moderate and high densities on the basis of Rainwater–Friend theory and the corresponding states principle

Hosseinnejad, T. and Behnejad, H. *Fluid Phase Equilibria*, 2008, 263, (1), 85–95.

The initial density dependence of viscosity and thermal conductivity was formulated on the basis of Rainwater–Friend (RF) theory. This work first focuses on the calculation of viscosity and thermal conductivity of moderately dense argon by using RF theory and an accurate *ab initio* potential function. This theory, which was originally presented for spherical potentials, has been adapted for calculation of viscosity and translational contribution of thermal conductivity of some refrigerants by introducing the corresponding states correlations for the second transport virial coefficients. Then the internal states contribution for the thermal conductivity has been determined based on the Mason–Monchick and modified Enskog theories. So, the viscosity and thermal conductivity was calculated of some refrigerants, R32, R14, R12, R13, R22, R134a, R143a, R125, R123, R142b, at moderate densities up to about 2 mol dm^{-3}. At high densities, beyond the validity range of RF theory, correlation expressions for the viscosity and thermal conductivity residual functions were applied to calculate the viscosity and thermal conductivity of supercritical refrigerants and then compared with the available experimental data. In conclusion, the study has shown that the RF theory in conjunction with the corresponding states residual functions present the reliable model for calculation of viscosity and thermal conductivity of refrigerants over a comparatively wide temperature and pressure range up to 65 MPa within the experimental errors.

11 ENGINES

Power generation and propulsion, electrical vehicles

08/01186 Aggregated dynamic model for wind farms with doubly fed induction generator wind turbines

Fernández, L. M. *et al. Renewable Energy*, 2008, 33, (1), 129–140.

As a result of increasing wind farms penetration in power systems, the wind farms begin to influence power system, and thus the modelling of wind farms has become an interesting research topic. Nowadays, doubly fed induction generator based on wind turbine is the most widely used technology for wind farms due to its main advantages such as high-energy efficiency and controllability, and improved power quality. When the impact of a wind farm on power systems is studied, the behaviour of the wind farm at the point common coupling to grid can be represented by an equivalent model derived from the aggregation of wind turbines into an equivalent wind turbine, instead of the complete model including the modelling of all the wind turbines. In this paper, a new equivalent model of wind farms with doubly fed induction generator wind turbines is proposed to represent the collective response of the wind farm by one single equivalent wind turbine, even although the aggregated wind turbines operate receiving different incoming winds. The effectiveness of the equivalent model to represent the collective response of the wind farm is demonstrated by comparing the simulation results of equivalent and complete models both during normal operation and grid disturbances.

08/01187 Analysis of local convective heat transfer in a spark ignition engine

Mohammadi, A. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (2), 215–224.

A computational fluid dynamics code is applied to simulate fluid flow, heat transfer and combustion in a four-stroke single cylinder engine with pent roof combustion chamber geometry, having two inlet valves and two exhaust valves. Heat flux and heat transfer coefficient on the cylinder head, cylinder wall, piston, intake and exhaust valves are determined with respect to crank angle position. Results for a certain condition are compared for total heat transfer coefficient of the cylinder engine with available correlation proposed by experimental measurement in the literature and close agreement are observed. It was found that the local value of heat transfer coefficient varies considerably in different parts of the cylinder, but they have equivalent trend with crank angle. Based on the results, new correlations are suggested to predict maximum and minimum convective heat transfer coefficient in the combustion chamber of a SI engine.

08/01188 Effect of water blending on bioethanol HCCI combustion with forced induction and residual gas trapping

Megaritis, A. *et al. Energy*, 2007, 32, (12), 2396–2400.

There is increased interest worldwide in renewable engine fuels as well as in new combustion technologies. Bioethanol is one of the alternative fuels that have been used successfully in spark ignition engines. A combustion technology that currently attracts a lot of interest is the homogeneous charge compression ignition (HCCI) combustion, which has shown potential for low nitrogen oxides emissions with no particulate matter formation. The authors have shown previously that applying forced induction to bioethanol HCCI with residual gas trapping results in an extended load range compared to naturally aspirated operation. However, at high boost pressures, high cylinder pressure rise rates develop. Work by other researchers has shown that direct injection of water can be used as a combustion control method. The present work explores water blending as a way that might have an effect on combustion in order to lower the maximum pressure rise rates and further improve emissions. The obtained experimental results show that in contrast to variable rate direct injection of water, fixed rate water–ethanol blending is counterproductive for the reduction of pressure rise rates at higher loads. In addition, increasing the water content in ethanol results in reduction of the effective load range and increased emissions.

08/01189 Exergetic analysis of an aircraft turbofan engine

Turgut, E. T. *et al. International Journal of Energy Research*, 2007, 31, (14), 1383–1397.

The main objective of the present study is to perform an exergy analysis of a turbofan kerosene-fired engine with afterburner (AB) at sea level and an altitude of 11 000 m. The main components of this engine include a fan, a compressor, a combustion chamber, a turbine, an AB and an exhaust. Exergy destructions in each of the engine components are determined, while exergy efficiency values for both altitudes are calculated. The AB unit is found to have the highest exergy destruction with 48.1% of the whole engine at the sea level, followed by the exhaust, the combustion chamber and the turbine amounting to 29.7, 17.2 and 2.5%, respectively. The corresponding exergy efficiency values for the four components on the product/fuel basis are obtained to be 59.9, 65.6, 66.7 and 88.5%, while those for the whole engine at the sea level and an altitude of 11,000 m are calculated to be 66.1 and 54.2%.

08/01190 Hybridization of powertrain and downsizing of IC engine – a way to reduce fuel consumption and pollutant emissions – part 1

Katrašnik, T. *Energy Conversion and Management*, 2007, 48, (5), 1411–1423.

The aim of this two part paper is to present the results of extensive simulation and analytical analysis of the energy conversion efficiency in parallel hybrid powertrains. The simulation approach is based on an accurate and fast forward facing simulation model of a parallel hybrid powertrain and a conventional internal combustion engine powertrain. The model of the ICE is based on a verified dynamic model that provides sufficiently small time steps to model adequately the dynamics of electric systems during transient test cycles. Models of the electrical devices enable computation of the instantaneous energy consumption, production and storage as well as computation of the instantaneous energy losses and component efficiencies. Moreover, the paper offers an analytical approach based on the energy balance in order to analyse and predict the energy conversion efficiency of hybrid powertrains. The analysis covers a broad range of parallel hybrid powertrain configurations from mild to full hybrids. Combined simulation and analytical analysis enables deep insight into the energy conversion phenomena in hybrid powertrains. The paper reveals the conditions and influences that lead to improved fuel economy of hybrid powertrains with the emphasis on determining the optimum hybridization ratio. The theoretical background, simulation program and brief analysis of one test cycle are presented in part 1, whereas the extensive analysis and parametric study is presented in the companion paper, part 2.

08/01191 Hybridization of powertrain and downsizing of IC engine – analysis and parametric study – part 2

Katrašnik, T. *Energy Conversion and Management*, 2007, 48, (5), 1424–1434.

The second part of the paper 'hybridization of powertrain and downsizing of IC engine' presents an extensive analysis and parametric study of hybrid powertrain parameters for different drive cycles and electric energy storage devices as well as the results of vehicle dynamics. The analysis is based on the simulation model and analytical groundwork presented in part 1. Very good agreement of the simulation and analytical results gives confidence in the accuracy of the performed analysis. Thus, the combined simulation and analytical analysis enables deep insight into the energy flow and energy loss phenomena in hybrid powertrains and reveals the advantages and disadvantages of hybrid powertrains running under different operating conditions. The analysis covers a broad range of parallel hybrid powertrain configurations spreading from mild- to full-hybrids. The aim of this paper is to indicate the influencing parameters that lead to an optimal combination of hybrid powertrain components in order to achieve an improved fuel economy of hybrid powertrains with the emphasis on drive cycle load as well as component sizes and efficiencies. It is shown in the paper that parallel hybrid powertrains exhibit considerable potential for higher energy conversion efficiency compared with conventional powertrains if their constituting components are sized adequately.

08/01192 Improving thermal efficiency by reducing cooling losses in hydrogen combustion engines

Shudo, T. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4285–4293.

Hydrogen can be readily used in spark ignition engines as a clean alternative to fossil fuels. However, the higher burning velocity and shorter quenching distance of hydrogen compared with hydrocarbons cause a larger heat transfer from the burning gas to the combustion chamber walls. Because of this cooling loss, the thermal efficiency of hydrogen-fueled engines is sometimes lower than that of conventionally fueled engines. Therefore, reducing the cooling loss is a crucial element in improving the thermal efficiency of hydrogen combustion engines. Previous research by the author and others has proposed the direct injection stratified charge as a technique for reducing the cooling loss in hydrogen combustion and shown its effect in reducing cooling loss through experiments in a constant volume combustion vessel. However, it is known that a reduction in cooling loss does not always improve thermal efficiency due to a simultaneous increase in the exhaust heat loss. This paper explains the relation between cooling loss reduction and thermal efficiency improvements by the direct injection stratified charge in hydrogen combustion engines.

08/01193 Modeling of internal combustion engine based cogeneration systems for residential applications

Onovwiona, Y. I. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 848–861.

A parametric model that can be used in the design and techno-economic evaluation of internal combustion engine (ICE) based cogeneration systems for residential use is presented. The model, which is suitable to be incorporated into a building simulation program, includes sub-models for internal combustion engines and generators, electrical/thermal storage systems, and secondary system components (e.g. controllers), and is capable of simulating the performance of these systems in 15-min time steps. Water storage tanks for thermal storage and electrochemical (battery) systems for electrical storage are modelled. The parametric model provides users with useful information about the cogeneration system performance in response to a building's electrical and thermal demands. This paper presents the model, and the results of sensitivity analyses obtained using the model with a building simulation program. The results demonstrate the capabilities of the model and provide an insight into the energetic performance of ICE based cogeneration systems.

08/01194 Occult parasitic energy loss in heat engines

Tinker, F. A. *International Journal of Energy Research*, 2007, 31, (14), 1441–1453.

When a reversible process, such as the compression of a working gas, is treated as a feedback mechanism coupling adjacent heat engine cycles, analysis reveals a parasitic energy loss unaccounted for by traditional theory. Including this feedback-induced energy loss in the derivation of an efficiency relation yields predictions that reproduce experimental observations with sufficient accuracy as to propose this effect as being the primary source of disparity between practice and existing theory. Further, it is shown that both the Carnot and Curzon–Ahlborn efficiency relations are derivable special cases of this more general result. Finally, it is postulated that substantial gains in thermodynamic efficiency may be affected in practical heat engines, including increases on the order of 30% in internal combustion engines, by frustrating these feedback mechanisms through simple mechanical modifications.

08/01195 Optimization of the direct Carnot cycle

Feidt, M. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 829–839.

A model for the study and optimization of two heat reservoirs thermal machines is presented. The mathematical model basically consists of the first and second laws of thermodynamics applied to the cycle and entire system, and the heat transfer equations at the source and sink. The internal and external irreversibilities of the cycle are considered by taking into account the entropy generation terms. Several constraints imposed to the system composed by the engine and the two heat reservoirs (namely, engine efficiency, or power output, or heat flux received by the engine, each of them together with imposed internal entropy generation and total number of heat transfer units of the machine heat exchangers) allow one to find the optimum operational conditions, as well as the limited variation ranges for the system parameters. Emphasis is put on coupling between various possible objective functions, namely thermal cost, useful effect, first law efficiency and whole system dissipation. It is for the first time to the authors' knowledge when it has been proved that if one of the possible objective functions is fixed (as a parameter with imposed value), the optima of the other three always correspond to each other for the corresponding stationary state system, with a given optimum heat conductance allocation (one degree of freedom). Other interesting results are also reported in this paper. Some sensitivity studies were developed, too, with respect to various parameters of the model (engine performance, internal entropy generation, total number of heat transfer units).

08/01196 Performance investigation of 2.4 kW PEM fuel cell stack in vehicles

Corbo, P. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4340–4349.

The aim of this paper was to investigate the behaviour of a 2.4 kW PEM stack in dynamic conditions typical of vehicle applications, including urban driving cycles taken from European legislation. A management strategy of the main fuel cell system auxiliary components was chosen with the scope of minimizing the energy consumptions associated to humidification, cooling and reactant feeding operations. The results obtained provided the definition of a correlation diagram power-temperature, in particular the application of a statistical indicator of the cell voltage uniformity (coefficient of variation C_v) allowed the specification of a reliable working field in terms of stack durability in real applications. The tests effected on European driving cycles R40 and R47 evidenced that stack power increase rates up to 500 W/s were acceptable for the fuel cell system used in this paper, while for higher dynamics the stack working regularity was limited by low stoichiometric ratio values ($R < 1$). However, during fast transient phases (10 s as order of magnitude) excursions outside the optimal conditions of power, temperature and R resulted acceptable in terms of C_v (mostly lower than 4%).

08/01197 Performance, emission and combustion studies of a DI diesel engine using Distilled Tyre pyrolysis oil-diesel blends

Murugan, S. *et al. Fuel Processing Technology*, 2008, 89, (2), 152–159.

Increase in energy demand, stringent emission norms and depletion of oil resources led the researchers to find alternative fuels for internal combustion engines. Many alternate fuels like alcohols, biodiesel, LPG, CNG, etc., have been already commercialized in the transport sector. In this context, pyrolysis of solid waste is currently receiving renewed interest. The disposal of waste tyres can be simplified to some extent by pyrolysis. The properties of the tyre pyrolysis oil (TPO) derived from waste automobile tyres were analysed and compared with the petroleum products and found that it can also be used as a fuel for compression ignition engine. However, the crude TPO has a higher viscosity and sulfur content. The crude TPO was desulfurized and then distilled through vacuum distillation. In the present work, DTPO-diesel blends were used as an alternate fuel in a diesel engine without any engine modification. This paper presents the studies on the performance, emission and combustion characteristics of a single cylinder four stroke air-cooled DI diesel engine running with the distilled tyre pyrolysis oil (DTPO).

08/01198 Simulation, construction and testing of a two-cylinder solar Stirling engine powered by a flat-plate solar collector without regenerator

Tavakolpour, A. R. *et al. Renewable Energy*, 2008, 33, (1), 77–87.

In this research, a gamma-type, low-temperature differential solar Stirling engine with two cylinders was modelled, constructed and primarily tested. A flat-plate solar collector was employed as an in-built heat source, thus the system design was based on a temperature difference of 80 °C. The principles of thermodynamics as well as Schmidt theory were adapted to use for modelling the engine. To simulate the system some computer programs were written to analyse the models and the optimized parameters of the engine design were determined. The optimized compression ratio was computed to be 12.5 for solar application according to the mean collector temperature of 100 °C and sink temperature of 20 °C. The corresponding theoretical efficiency of the engine for the mentioned designed parameters was calculated to be 0.012 for zero regenerator efficiency. Proposed engine dimensions are as follows: power piston stroke 0.044 m, power piston diameter 0.13 m, displacer stroke 0.055 m and the displacer diameter 0.41 m. Finally, the engine was tested. The results indicated that at mean collector temperature of 110 °C and sink temperature of 25 °C, the engine produced a maximum brake power of 0.27 W at 14 rpm. The mean engine speed was about 30 rpm at solar radiation intensity of 900 W/m^2 and without load. The indicated power was computed to be 1.2 W at 30 rpm.

08/01199 Technological development in the Stirling cycle engines

Thombare, D. G. and Verma, S. K. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 1–38.

The performance of Stirling engines meets the demands of the efficient use of energy and environmental security and therefore they are the subject of much current interest. Hence, the development and investigation of Stirling engine have come to the attention of many scientific institutes and commercial companies. The Stirling engine is both practically and theoretically a significant device, its practical virtue is simple, reliable and safe which was recognized for a full century following its invention by Robert Stirling in 1816. The engine operates on a closed thermodynamic cycle, which is reversible. Today Stirling cycle-based systems are in commercial use as a heat pump, cryogenic refrigeration and air liquefaction. As a prime mover, Stirling cycles remain the subject of research and development efforts. The objective of this paper is to provide fundamental information and present a detailed review of the past efforts taken for the development of the Stirling cycle engine and techniques used for engine analysis. A number of attempts have been made by researches to build and improve the performance of Stirling engines. It is seen that for successful operation of engine system with good efficiency a careful design of heat exchangers, proper selection of drive mechanism and engine configuration is essential. The study indicates that a Stirling cycle engine working with relatively low temperature with air of helium as working fluid is potentially attractive engines of the future, especially solar-powered low-temperature differential Stirling engines with vertical, double acting, and gamma configuration.

08/01200 The fluid dynamics of a miniature dilution tunnel for internal-combustion engine aerosol measurement

Kommer, E. M. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (2), 475–488.

This paper investigates the fluid dynamics of a particular mini-dilution tunnel using LDV, flow visualization, a tracer sample technique and CFD. The mini-dilution tunnel studied had a 3.175 mm inside diameter tube discharging on the centreline of the tunnel where the diameter increases in a single step to 7.62 cm. The large diameter portion of the tunnel was 75 cm long. Most of the testing was performed at a flow rate of 15 l/min. The experimental investigation indicates that the flow field in the particular dilution tunnel tested has a persistent jet throughout its length, and this confined jet creates eddy recirculation zones which may cause the temperature and dilution histories of particles trapped in these eddies to be significantly different than particles which remain in the jet until extracted by the sample probe. Similarly, the location of the sample probe could also affect measured size distribution profiles, particularly if it were moved in or out of the path of the persistent jet. In addition to the simple tunnel geometry with a single abrupt expansion, a conical diffuser and a perforated plate were separately tested to investigate their effects on the tunnel fluid dynamics. The particular diffuser tested appeared to cause the jet to stall and therefore led to an even more unpredictable path for the fluid within. Limited testing with the perforated plate indicated that it increased the jet deceleration and laminarization, and therefore could lead to a more predictable flow path for aerosol sampled from the tunnel.

Hybrid engine systems

08/01201 Analysis of potential fuel consumption and emissions reductions from fuel cell auxiliary power units (APUs) in long-haul trucks

Lutsey, N. *et al. Energy*, 2007, 32, (12), 2428–2438.

The idling of heavy-duty trucks results in additional emissions, fuel consumption and cost. Small fuel cell auxiliary power units (APUs) (now in development) are promising alternatives to idling the main engine. A solid oxide fuel cell (SOFC) APU is particularly attractive, because in conjunction with a reformer, it could operate on widely available diesel fuel. Because fuel cell APUs may not only reduce environmental impacts, but also reduce operating costs, this application has been cited as an attractive early market niche for fuel cells. The objective is to determine whether SOFC APUs are likely to soon be economically feasible for those trucks that idle most and what energy and environmental benefits are probable. The APU market size is estimated as a function of APU costs by applying Monte Carlo sampling and net present value economic analysis to the ADVISOR-based vehicle fuel consumption model. Emissions and fuel economy benefits estimates are then presented as a function of varying market penetration levels, assuming installation on only new vehicles and removal at the end of the 4-year SOFC lifecycle. With modest economic incentives from government and continuing fuel cell technology improvements, the authors find that SOFC APUs might be economically feasible for up to 15% of the long-haul truck population (60,000 trucks) in the United States in the 2015 time frame, resulting in a 30% reduction of heavy-duty truck fuel use during overnight idling and a 40% reduction in oxides of nitrogen (NO_x) produced during idling.

08/01202 Energy and exergy analysis of internal reforming solid oxide fuel cell–gas turbine hybrid system

Bavarsad, P. G. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4591–4599.

The aim of this work is to analyse methane-fed internal reforming solid oxide fuel cell–gas turbine (IRSOFC – GT) power generation system based on the first and second law of thermodynamics. Exergy analysis is used to indicate the thermodynamic losses in each unit and to assess the work potentials of the streams of matter and of heat interactions. The system consists of a prereformer, a SOFC stack, a combustor, a turbine, a fuel compressor and air compressor, recuperators and a heat recovery steam generator (HRSG). A parametric study is also performed to evaluate the effect of various parameters such as fuel flow rate, air flow rate, temperature and pressure on system performance.

08/01203 Experimental study on a spark ignition engine fuelled by methane–hydrogen mixtures

Akansu, S. O. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4279–4284.

In this study, effects on a spark ignition engine of mixtures of hydrogen and methane have been experimentally considered. This article presents the results of a four-cylinder engine test with mixtures of hydrogen in methane of 0, 10, 20 and 30% by volume. Experiments have been made varying the equivalence ratio. Equivalence ratios have been selected from 0.6 to 1.2. Each fuel has been investigated at 2000 rpm and constant load conditions. The result shows that NO emissions increase, HC, CO and CO_2 emission values decrease and brake thermal efficiency (BTE) values increase with increasing hydrogen percentage.

08/01204 Performance and emission characteristics of turpentine-diesel dual fuel engine and knock suppression using water diluents

Karthikeyan, R. and Mahalakshmi, N. V. *International Journal of Energy Research*, 2007, 31, (10), 960–974.

In the present work, a normal diesel engine was modified to work in a dual fuel (DF) mode with turpentine and diesel as primary and pilot fuels, respectively. The resulting homogeneous mixture was compressed to a temperature below the self-ignition point. The pilot fuel was injected through the standard injection system and initiated the combustion in the primary-fuel air mixture. The primary fuel (turpentine) has supplied most of the heat energy. Usually, in all DF engines, low-cetane fuels are preferred as a primary fuel. Therefore, at higher loads these fuels start knocking and deteriorating in performances. Usually, DF operators suppress the knock by adding more pilot-fuel quantity. But in the present work, a minimum pilot-fuel quantity was maintained constant throughout the test and a required quantity of diluent (water) was added into the combustion at the time of knocking. The advantages of this method of knock suppression are restoration of performance at full load, maintenance of the same pilot quantity through the load range and reduction in the fuel consumption at full load. From the results, it was found that all performance and emission parameters of turpentine, except volumetric efficiency, are better than those of diesel fuel. The emissions like CO, UBHC are higher than those of the diesel baseline and around 40–45% reduction of smoke was observed at 100% of full load. The major pollutant of diesel engine, NO_x, was found to be equal to that of DFL. From the above experiment, it was proved that approximately 80% replacement of diesel with turpentine is quite possible.

08/01205 Study on capacity optimization of PEM fuel cell and hydrogen mixing gas-engine compound generator

Obara, S. and Tanno, I. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4329–4339.

Development of a small-scale power source not dependent on commercial power may result in various effects. For example, it may eliminate the need for long distance power-transmission lines, and mean that the amount of green energy development is not restricted to the dynamic characteristics of a commercial power grid. Moreover, the distribution of the independent energy source can be optimized with regionality in mind. This paper examines the independent power supply system relating to hydrogen energy. Generally speaking, the power demand of a house tends to fluctuate considerably over the course of a day. Therefore, when introducing fuel cell cogeneration into an apartment house, etc., low-efficiency operations in a low-load region occur frequently in accordance with load fluctuation. Consequently, the hybrid cogeneration system (HCGS) that uses a solid polymer membrane-type fuel cell (PEM-FC) and a hydrogen mixture gas engine (NEG) together to improve power generation efficiency during partial load of fuel cell cogeneration is proposed. However, since facility costs increase, if the HCGS energy cost is not low compared with the conventional method, it is disadvantageous. Therefore, in this paper, HCGS is introduced into 10 household apartments in Tokyo, and the power generation efficiency, carbon dioxide emissions and optimal capacity of a boiler and heat storage tank are investigated through analysis. Moreover, the system characteristics change significantly based on the capacity of PEM-FC and NEG that compose HCGS. Therefore, in this study, the capacity of PEM-FC and that of NEG are investigated, as well as the power generation efficiency, carbon dioxide emissions and the optimal capacity of a boiler and heat storage tank. Analysis revealed that the annual average power generation efficiency when the capacity of PEM-FC and NEG is 5 kW was 27.3%. Meanwhile, the annual average power generation efficiency of HCGS is 1.37 times that of the PEM-FC independent system, and 1.28 times that of the NEG independent system, respectively.

Transport battery development

08/01206 Economics and market prospects of portable fuel cells

Agnolucci, P. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4319–4328.

This paper reviews the literature on the market introduction of portable fuel cells, i.e. portable generators and microfuel cells. After discussing the benefits of these products, and surveying the projections of their costs and market forecasts, conclusions on the business models of the main actors in the portable fuel cell sectors are drawn. Perhaps because there has been a great deal of imprecision in defining the costs and benefits of portable fuel cells, market forecasts have been in some cases extremely optimistic. It can be concluded that fuel cells will hit the market later than previously envisaged and that they are unlikely to become popular through hybridization with batteries, i.e. portable chargers. Although microfuel cells are likely to become a mass-marketed product, they first need to become an ordinary one and this will happen only when users will be unable to distinguish between electronic devices powered by fuel cells and those powered by batteries, with the exception of the different amounts of energy supplied. Otherwise, portable fuel cells are likely to be confined to a small niche of power-thirsty professional users.

12 REFRACTORIES/ CERAMICS

Properties, production, applications

08/01207 A review on the use of waste glasses in the production of cement and concrete

Shi, C. and Zheng, K. *Resources, Conservation and Recycling*, 2007, 52, (2), 234–247.

The use of recycled waste glasses in Portland cement and concrete has attracted a lot of interest worldwide due to the increased disposal costs and environmental concerns. Being amorphous and containing relatively large quantities of silicon and calcium, glass is, in theory, pozzolanic or even cementitious in nature when it is finely ground. Thus, it can be used as a cement replacement in Portland cement concrete. The use of crushed glasses as aggregates for Portland cement concrete does have some negative effect on properties of the concrete; however, practicle applicability can still be produced even using 100% crushed glass as aggregates. The main concerns for the use of crushed glasses as aggregates for Portland cement concrete is the expansion and cracking caused by the glass aggregates. This paper summarizes the progresses and points out the directions for the proper uses of waste glasses in Portland cement and concrete.

08/01208 Bond performance of polystyrene aggregate concrete (PAC) reinforced with glass-fibre-reinforced polymer (GFRP) bars

Tang, W. C. *et al. Building and Environment*, 2008, 43, (1), 98–107.

This paper concerns the bond performance of GFRP bars in polystyrene aggregate concrete (PAC) by the proposed concentric pullout test. Identical specimens reinforced with mild steel bars were used for comparison. The bond performance including the mode of failure and bond strength was studied with varying polystyrene aggregate content, concrete strength, embedment length, shape and surface treatment of the bars. Empirical formulae were developed for the estimation of development length on the basis of the pullout test results. The bond development length (l_d) determined according to ACI Building Code was used for comparison. Considering the bond performance, the sand-coated GFRP bar gave the most promising results with the highest bond strength attained. In particular, the bond strength was found increased with the compressive strength and concrete density of PAC. Besides, the bond development length for PAC reinforced with GFRP bars can be predicted satisfactorily using the ACI equation.

08/01209 Ceramic matrices for plutonium disposition

Ewing, R. C. *Progress in Nuclear Energy*, 2007, 49, (8), 635–643.

One of the major issues related to the expanded use of nuclear power and the development of advanced nuclear fuel cycles is the fate of plutonium and ‘minor’ actinides. In addition, substantial quantities of plutonium and highly enriched uranium from dismantled nuclear weapons now require disposition. There are two basic strategies for the disposition of the actinides: (1) to ‘burn’ or transmute the actinides using nuclear reactors or accelerators; (2) to ‘sequester’ the actinides in chemically durable, radiation-resistant materials that are suitable for geologic disposal. This paper deals with actinide-bearing materials that support the latter approach. During the past two decades, a considerable amount of research and development has been done in an effort to develop matrices for the immobilization of plutonium and the ‘minor actinides’, Np, Am and Cm. A variety of waste form materials – oxides, silicates and phosphates – have been developed that have a high capacity for the incorporation of actinides, are chemically durable and, in some cases, resistant to the radiation-induced transformation to the aperiodic state. These waste forms can be selected depending on the composition of the waste stream that contains the actinides, the desired materials’ properties of the waste form, and the geochemical and hydrologic conditions of the specific repository. The present state-of-knowledge for these materials is such that now one can design materials for very specific conditions, such as the thermal history and accumulated radiation dose, in a repository.

08/01210 Dependence of particle size distribution upon brittleness in glass

Hwang, S. and Kim, H. *Journal of the European Ceramic Society*, 2008, 28, (1), 193–197.

The size reduction of glasses is dependent on the impact energy and their brittleness. In milling, the particle size distribution is especially related to the glass brittleness, which can be predicted by the experimentally determined elastic modulus. The correlation of glass mechanical properties with particle size distribution during dry milling was investigated. The $D_{50\text{–}90}$ particle size distribution and mean particle size were related to the glass brittleness. The authors suggest that the relationship between frit size distribution and brittleness should be considered for efficient pulverization, and further that the glass brittleness can be predicted by the elastic modulus of glasses.

08/01211 Determination of the origin of the illumination vector due to vertical windows under Moon-Spencer sky conditions (uniformly overcast)

Navarro, J. and Sendra, J. J. *Renewable Energy*, 2008, 33, (1), 168–172.

This paper provides a procedure of easy approximation to obtain the direction of the illumination vector for a window under an overcast sky. When working with uniform skies, it is simple to demonstrate that the direction of the illumination vector is determined by the centre of the window and the illuminated point. However, when a luminance distribution is produced such as that specified by the Moon-Spencer law, the origin of the vector is no longer the centre of the window, but some point within a fragment of the window. In this paper, this fragment of window is delimited.

08/01212 Development of the nomo-graph for evaluation on discomfort glare of windows

Lee, J. S. and Kim, B. S. *Solar Energy*, 2007, 81, (6), 799–808.

Daylight provides building occupants with psychological stability and also serves as lighting. However, the discomfort glare of windows produced from the daylight could be a severe problem as the working condition is getting more complicated and precise. Although numerous studies have been performed in order to solve this problem, most studies have been performed on Caucasians. The recent studies have revealed that there were differences between Caucasians and Asians in ocular activity, pigmentation, and colour sensibility depending on the iris colour. These data implies that it is difficult to directly apply the data from studies on the Caucasian to Asians whose physiological properties of eyes are different from those of the Caucasian. Therefore, it is necessary to develop an evaluation method of window discomfort glare, which may represent the visual feature of Asian appropriately. In the present study, the authors investigated the visual difference between Caucasian and Asians and established the nomo-graph to develop the method appropriate for the evaluation of the window discomfort glare for Asians.

08/01213 Effects of pore sizes of porous silica gels on desorption activation energy of water vapour

Li, X. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 869–876.

In this work, the effects of pore sizes of silica gel on desorption activation energy and adsorption kinetics of water vapour on the silica gels were studied. The isotherms and adsorption kinetic curves of water vapour on three kinds of silica gels with average pore diameters of 2.0 nm, 5.28 nm and 10.65 nm, respectively, were measured by the method of static adsorption, the desorption activation energies of water vapour on silica gels were estimated by using the TPD technique, and the effects of pore sizes of silica gel on adsorption kinetics and desorption activation energy were discussed. Results showed that the isotherm of water vapour on the A-type silica gel with the average pore diameter of 2 nm was of type I, which can be well described by the Langmuir model; the isotherms of water vapour on the B-type and the C-type mesoporous silica gels with the average pore diameters of 5.28 nm and 10.65 nm, respectively, were of type V; and at lower RH, the smaller the average pore size of the silica gel was, the smaller the adsorption rate constant was due to the diffusion resistance in the pores of the silica gels, while at a higher RH, the smaller the average pore size of the silica gel was, the larger the adsorption rate constant was. The desorption activation energies of water on the A-type, the B-type and the C-type silica gels were respectively 35.54, 31.41 and 26.16 kJ/mol, which suggested that the desorption activation energy of water on the silica gels increased as the pore sizes of the silica gels decreased.

08/01214 Experimental and numerical determination of the total solar energy transmittance of glazing with venetian blind shading

Simmler, H. and Binder, B. *Building and Environment*, 2008, 43, (2), 197–204.

In response to the increased occurrence of overheating problems in glazed buildings in recent years, EMPA has focused on the determination and modelling of the total solar energy transmittance (TSET) of multiple glazing combined with different shading systems. Measurements were performed in a calorimetric outdoor test facility near Zurich, Switzerland. In the first phase, average TSET-values related to the incident global solar radiation were identified for various Venetian blind configurations with a measurement period of a few days each. As expected the results strongly depend on the slat tilt angle as well as on the solar reflectance of the slat surface. The influence of the directional distribution of the incident radiation is demonstrated by comparison of results from different measuring periods with the identical shading–glazing configuration. An extended identification model accounting for the angle-selective transmittance is presented. The experimental results are also compared with weighted *g*-values from numerical modelling, which are based on a view factor method extended for curved slats in a louvre type shading device. In general, the agreement between the measured and calculated results is satisfactory. Some deviation is explained by a significant non-diffuse albedo component in the hemispherical radiation field.

08/01215 On minimizing heat transport in architectural glazing

Manz, H. *Renewable Energy*, 2008, 33, (1), 119–128.

Significant reductions in the heating energy demand of buildings are achievable through minimization of the thermal transmittance of glazing. This paper reviews all the heat transport processes occurring in gas-filled and evacuated insulating glazing. The heat transfer mechanisms in gas-filled glazing cavities include radiative exchange between the glass sheet surfaces, convection and gaseous conduction. The application of two low-emissivity coatings (0.04) lowers the thermal conductance due to radiation between the glass pane surfaces to roughly $0.1\,\mathrm{W\,m^{-2}\,K^{-1}}$. At the same time, even where fill gases such as krypton and xenon are used, thermal conductance due to convection and conduction cannot be reduced to much below $1\,\mathrm{W\,m^{-2}\,K^{-1}}$. Heat transfer by convection and gaseous conduction only becomes negligible where the cavity is evacuated to approximately 10^{-2} Pa. Heat transfer is then determined by radiation and, even more importantly, conduction in support pillars required to bear the atmospheric load on the external glass sheet surfaces. The fact that the average centre-of-glazing heat transfer rates achievable by evacuation of the cavity are some two to five times lower than those of gas-filled cavities increases the significance of heat transfer in the glazing edge regions. Consequently, in addition to the heat transfer in the cavity, the impact on glazing thermal transmittance of the edge seal and different frame constructions was also quantified. The possibilities and limitations of reducing total heat transfer in evacuated glazing are discussed on the basis of analytical and numerical methods. The results suggest that this concept offers significant advantages over current glazing technology in terms of overall thermal transmittance.

08/01216 Plutonium solubility and self-irradiation effects in borosilicate glass

Deschanels, X. *et al. Progress in Nuclear Energy*, 2007, 49, (8), 623–634.

This article presents the limitations for the immobilization of plutonium in borosilicate glasses. A first one is related to the solubility of this element in glass. The effects of the temperature and redox conditions during glass processing were studied. Glass specimens containing plutonium and plutonium surrogates are fabricated. The results show that trivalent elements (La, Gd, Nd, etc.) exhibit greater solubility than tetravalent elements (Pu, Th, Hf). Fabricating the plutonium-doped glass samples under reductive conditions reduced the Pu to trivalent oxidation state and increased its solubility to 4 wt% PuO_2 without reaching the solubility limit. A structural approach based on the results of EXAFS and NMR spectroscopy suggests that the structural role of the trivalent and tetravalent elements corresponds to that of intermediate network modifiers and intermediate network formers, respectively. The second factor is the effect of actinide decay on the long-term behaviour of the glass. Borosilicate glass samples were doped with different curium contents (0.05, 0.5, 1.5 and 4.1 wt% of CmO_2). The macroscopic properties (density, microhardness and initial dissolution rate) of the glasses were characterized up to $4 \times 10^{18}\,\alpha\,g^{-1}$. No significant effect on the initial alteration rate was detected. The glass swelled slightly, saturating at about 0.5% after receiving a dose of about $2 \times 10^{18}\,\alpha\,g^{-1}$. Further studies are ongoing to confirm the satisfactory long-term behaviour of the borosilicate glass matrix at higher doses, and to determine the solubility limit of plutonium in reducing conditions.

08/01217 Sol–gel preparation and characterization of Ni–YSZ cermet electrode

Ohga, E. *et al. Progress in Nuclear Energy*, 2007, 49, (7), 546–554.

Optimizing both the internal gelation (IGP) and ethylene-diamine-tetra-acetic acid (EDTA) complexes-gel reduction process (CGRP) was carried out for manufacturing Ni–YSZ (yttria-stabilized zirconia) cermet as the membrane electrode. For the IGP, the authors found the adequate additive amounts of gelling agent and stabilizer such as HMTA (hexamethylenetetramine) and urea for the starting solution, so that precursor gels containing Ni content of 45–61.3 mol% were successfully synthesized. However, the sample prepared via IGP did not show the electronic conductivity but ionic one, although NiO in the samples was completely reduced to Ni. This might be caused by a decrease of Ni content during sintering at high temperature. On the other hand, for EDTA CGRP, precursor gels were successfully synthesized by controlling pH value in the preparation of soluble complexes. In addition, the sample synthesized via EDTA CGRP showed the electronic conductivity for Ni content of 60 mol%.

08/01218 Solar material protection factor and solar skin protection factor for window panes and other glass structures in buildings

Jelle, B. P. *et al. Solar Energy Materials and Solar Cells*, 2007, 91, (4), 342–354.

The two quantities, solar material protection factor (SMPF) and solar skin protection factor (SSPF), are introduced in order to measure and calculate the capability of glass to protect indoor materials and human skin from degradation caused by the solar radiation. Comparison of the SMPF and SSPF values for different glass fabrications enables one to select the most appropriate glass material for the specific buildings. Numerical examples are shown with measurements and calculations carried out on various glass materials, including two electrochromic window devices, and several two- and three-layer window pane combinations. Visibility levels at various protection degrees are also given.

08/01219 The effect of packing structure of powder particles on warping during sintering

Chantaramee, N. *et al. Journal of the European Ceramic Society*, 2008, 28, (1), 21–25.

In this study, aqueous alumina suspension consisting of constant solid loading was chosen as a model system in order to observe the effect of particle packing structure in green tape on sintering deformation. The specific particle packing structure in consolidated green tape was intentionally formed during tape casting, for instance, a non-uniform particle packing structure (Type-I) and a relatively uniform particle packing structure (Type-II). The development of deformation in sintered specimens was explainable from anisotropic packing structure. Alumina tapes with Type-I structure particularly showed warping which was transverse to the casting direction. Tapes with Type-II structure appeared with irregular distortion which was expected as a result of the localized non-uniform particle packing structure.

08/01220 The role of the PASLINK test cell in the modelling and integrated simulation of an innovative window

Leal, V. and Maldonado, E. *Building and Environment*, 2008, 43, (2), 217–227.

The SOLVENT window is an innovative glazing system concept that involves the use of a rotating frame, an absorptive glazing and a naturally ventilated vertical channel, in order to improve the balance between the visual comfort and the energy efficiency of windows. The tools available for simulating the behaviour of the window in terms of visual comfort and of thermal and energetic behaviour are complex and potentially dependent on many calibration parameters, such as the heat convection coefficients and the number of nodes in an air-flow network. Different modelling approaches can lead to large variability in the results obtained. It is thus essential that the models are supported by measurements that may, on one hand, help to optimize the component modelling and, on the other hand, ensure that the global results provided by the model are realistic. In the case of the

SOLVENT window, a prototype mounted on a PASLINK test cell in Porto (Portugal) played a fundamental role in this process. The monitoring results were used to: (a) assess the quality of the results obtained with a base case model, (b) develop improved models for the air flow and for the heat convection in the vertical air channel, (c) validate the results for the global heating and cooling loads obtained with the optimized model, and (d) calibrate the parameters needed for accurate daylighting simulation with Radiance. Once the component model was optimized and validated, it was then applied in realistic global building models for detailed performance studies. An example is provided in this paper for the virtual application of the SOLVENT window to an office in Porto, Portugal.

08/01221 Thermoelectric properties of porous SiC/C composites

Fujisawa, M. *et al. Renewable energy*, 2008, 33, (2), 309–313.
We developed a porous SiC/C composite by oxidizing a SiC/C composite made from a mixed powder of wood charcoal and SiO_2 (32–45 µm) by pulse current sintering at 1600 and 1800 °C under a N_2 atmosphere. The microstructures of the porous SiC/C composites with oxidation and the SiC/C composites without oxidation were analysed by Raman spectroscopy and scanning electron microscopy (SEM). Raman spectra revealed the disappearance of excess carbon and the presence of β-SiC. The porous microstructure was monitored by SEM observation as a function of the heat treatment temperature. The thermoelectric properties of porous SiC/C composites with oxidation and SiC/C composites without oxidation were investigated by measuring the Seebeck coefficient, the electrical conductivity and thermal conductivity. The Seebeck coefficient of all samples revealed n-type conduction, and the absolute value of the Seebeck coefficient for the porous SiC/C samples with oxidation was much larger than that for the SiC/C samples without oxidation. For the electrical conductivity the reverse is true. Only the thermal conductivity of the SiC/C sample heated to 1800 °C without oxidation was high initially and stayed rather high. In general, the thermoelectric properties improved at higher measurement temperatures indicating their suitability for high-temperature thermoelectric conversion. A maximum figure of merit of $2.01 \times 10^{-5}\,K^{-1}$ was obtained at 700 °C in porous SiC/C samples sintered at 1800 °C with oxidation.

08/01222 Thin film polycrystalline silicon solar cells on mullite ceramics

Focsa, A. *et al. Renewable energy*, 2008, 33, (2), 267–272.
This work presents the structural quality of polycrystalline silicon films formed by high-temperature chemical vapour deposition (CVD) on mullite ceramics coated with spin-on flowable oxides (FO_x) serving as intermediate layers (ILs). The average grain size and the size distribution were investigated by optical microscopy. It is found that more than 65% of the surface of polysilicon films grown on boron-doped FO_x is covered by large grains of 5–10 µm. The intra-grain and inner-grain defects as well as the grain orientation were analysed with the electron backscattering diffraction (EBSD) technique. Twin-type defects such as $\Sigma3$ and $\Sigma9$ are frequently present in these silicon layers, which are slightly (1 1 0) preferentially oriented. Finally, the authors present the photovoltaic data on test solar cells made on these CVD polysilicon films. An efficiency of about 3.3% is reported. The limiting factors, as well as possible improvements, are discussed.

13 ALTERNATIVE ENERGY SUPPLIES

Biofuels and bioconversion energy

08/01223 A prospective study of bioenergy use in Mexico

Islas, J. *et al. Energy*, 2007, 32, (12), 2306–2320.
Bioenergy is one of the renewable energy sources that can readily replace fossil fuels, while helping to reduce greenhouse gas emissions and promoting sustainable rural development. This paper analyses the feasibility of future scenarios based on moderate and high use of biofuels in the transportation and electricity generation sectors with the aim of determining their possible impact on the Mexican energy system. Similarly, it evaluates the efficient use of biofuels in the residential sector, particularly in the rural sub-sector. In this context, three scenarios are built within a time frame that goes from 2005 to 2030. In the base scenario, fossil fuels are assumed as the dominant source of energy, whereas in the two alternative scenarios moderate and high biofuel penetration diffusion curves are constructed and discussed on the basis of their technical and economical feasibility. Simulation results indicate that the use of ethanol, biodiesel and electricity obtained from primary biomass may account for 16.17% of the total energy consumed in the high scenario for all selected sectors. CO_2 emissions reduction – including the emissions saved from the reduction in the non-sustainable use of fuelwood in the rural residential sector – is equivalent to 87.44 million tons of CO_2 and would account for 17.84% of the CO_2 emitted by electricity supply and transportation sectors when the base case and the high scenario are compared by 2030.

08/01224 Analysis and upgrading of bio-petroleum from biomass by direct deoxy-liquefaction

Li, J. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (2), 199–204.
Bio-petroleum with unusual H/C molar ratio of 1.90 and higher heating value of 44.22 MJ/kg was obtained from soybean stalk by deoxy-liquefaction (deoxygenation in the process of liquefaction). This bio-petroleum had similar composition to fossil petroleum which contains long-chain alkanes and aromatic hydrocarbons. The oil with H/C molar ratio of 2.00 and the higher heating value of 46.95 MJ/kg was obtained after bathing with 1% NaOH solution by refluxing. And then this bathed bio-petroleum was directly distilled and the fractions were boiled under <120 °C, 120–180 °C, 180–240 °C, 240–350 °C, respectively, of which the distillate of 240–350 °C was almost the same with diesel oil in composition and could be used as a substitute transport fuel after decolorization using activated clay.

08/01225 Bio-fuels from thermochemical conversion of renewable resources: a review

Goyal, H. B. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 504–517.
Demand for energy and its resources, is increasing every day due to the rapid outgrowth of population and urbanization. As the major conventional energy resources like coal, petroleum and natural gas are at the verge of getting extinct, biomass can be considered as one of the promising environment friendly renewable energy options. Different thermo-chemical conversion processes that include combustion, gasification, liquefaction, hydrogenation and pyrolysis, have been used to convert the biomass into various energy products. Although pyrolysis is still under developing stage but during current energy scenario, pyrolysis has received special attention as it can convert biomass directly into solid, liquid and gaseous products by thermal decomposition of biomass in absence of oxygen. In this review article, the focus has been made on pyrolysis while other conventional processes have been discussed in brief. For having better insight, various types of pyrolysis processes have been discussed in detail including slow, fast, flash and catalytic pyrolysis processes. Besides biomass resources and constituents, the composition and uses of pyrolysis products have been discussed in detail. This review article aim to focus on various operational parameters, viz. temperature and particle size of biomass and product yields using various types of biomasses.

08/01226 Biofuels generation from sweet sorghum: fermentative hydrogen production and anaerobic digestion of the remaining biomass

Antonopoulou, G. *et al. Bioresource Technology*, 2008, 99, (1), 110–119.
The present study focuses on the exploitation of sweet sorghum biomass as a source for hydrogen and methane. Fermentative hydrogen production from the sugars of sweet sorghum extract was investigated at different hydraulic retention times (HRT). The subsequent methane production from the effluent of the hydrogenogenic process and the methane potential of the remaining solids after the extraction process were assessed as well. The highest hydrogen production rate (2550 ml H_2/d) was obtained at the HRT of 6 h while the highest yield of hydrogen produced per kg of sorghum biomass was achieved at the HRT of 12 h (10.41 H_2/kg sweet sorghum). It has been proved that the effluent from the hydrogenogenic reactor is an ideal substrate for methane production with approximately 29 l CH_4/kg of sweet sorghum. Anaerobic digestion of the solid residues after the extraction process yielded 78 l CH_4/kg of sweet sorghum. This work demonstrated that biohydrogen production can be very efficiently coupled with a subsequent step of methane production and that sweet sorghum could be an ideal substrate for a combined gaseous biofuels production.

08/01227 Biomass use in chemical and mechanical pulping with biomass-based energy supply

Holmberg, J. M. and Gustavsson, L. *Resources, Conservation and Recycling*, 2007, 52, (2), 331–350.
The pulp and paper industry is energy intensive and consumes large amounts of wood. Biomass is a limited resource and its efficient use is therefore important. In this study, the total amount of biomass used for pulp and for energy is estimated for the production of several woodfree (containing only chemical pulp) and mechanical (containing mechan-

ical pulp) printing paper products, under Swedish conditions. Chemical pulp mills today are largely self-sufficient in energy while mechanical pulp mills depend on large amounts of external electricity. Technically, all energy used in pulp- and papermaking can be biomass based. Here, it is assumed that all energy used, including external electricity and motor fuels, is based on forest biomass. The whole cradle-to-gate chain is included in the analyses. The results indicate that the total amount of biomass required per tonne paper is slightly lower for woodfree than for mechanical paper. For the biomass use per paper area, the paper grammage is decisive. If the grammage can be lowered by increasing the proportion of mechanical pulp, this may lower the biomass use per paper area, despite the higher biomass use per unit mass in mechanical paper. In the production of woodfree paper, energy recovery from residues in the mill accounts for most of the biomass use, while external electricity production accounts for the largest part for mechanical paper. Motor fuel production accounts for 5–7% of the biomass use. The biomass contained in the final paper product is 21–42% of the total biomass use, indicating that waste paper recovery is important. The biomass use was found to be about 15–17% lower for modelled, modern mills compared with mills representative of today's average technology.

08/01228 Comparison of corn and switchgrass on marginal soils for bioenergy

Varvel, G. E. *et al. Biomass and Bioenergy*, 2008, 32, (1), 18–21.

Crop residues such as corn (*Zea mays* L.) stover are viewed as an abundant and inexpensive source of biomass that can be removed from fields to produce bioenergy. Assumptions include that with minimum or no-tillage farming methods, there will be no deleterious production or environmental effects. A long-term field study was established in eastern Nebraska, USA, to compare the switchgrass managed as a biomass energy crop versus no-till corn on a non-irrigated site, marginal for row-crop production, in the western Corn Belt. The objective in this paper is to report on corn stover removal effects on corn grain yields and potential ethanol production in both cropping systems. Corn, under no-till management, and switchgrass were grown at three N fertilizer levels. In the first 5 years (2001–2005), removal of half the available stover significantly reduced corn yields. During that same time period, the potential ethanol yield for switchgrass was equal to or greater than the potential total ethanol yield of corn grain and harvested stover fertilized at the same optimum N rate. The effect of crop residue removal on crop productivity needs to be investigated in other agro-ecosystems and the potential use of dedicated perennial biomass energy crops should remain a viable renewable energy option on non-irrigated marginal croplands.

08/01229 Different action of alkali/alkaline earth metal chlorides on cellulose pyrolysis

Shimada, N. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 80–87.

The influence of alkali metal chlorides (NaCl, KCl) and alkaline earth metal chlorides ($MgCl_2$, $CaCl_2$) on cellulose pyrolysis was studied with thermal analysis and isothermal pyrolysis in N_2 at 150–400 °C. Alkali and alkaline earth metal chlorides affected the cellulose pyrolysis in different way. Although alkali metal chlorides did not change the weight loss temperature of bulk cellulose (main part of cellulose) so much, alkaline earth metal chlorides substantially reduced the temperature. Furthermore, the influence of alkaline earth metal chlorides on the weight loss behaviour ($<400\,°C$) was very dependent on the amount of loading bellow 0.30 mol/mol of the glucose-unit of cellulose, while the influences of the alkali metal chlorides were almost independent of the amount. Both metal chlorides significantly changes the low MW product composition even at a very low level of addition.

08/01230 Different enzyme requirements for the synthesis of biodiesel: Novozym® 435 and Lipozyme® TL IM

Hernández-Martín, E. and Otero, C. *Bioresource Technology*, 2008, 99, (2), 277–286.

Enzymatic syntheses of biodiesel via alcoholysis of different vegetable oils (sunflower, borage, olive and soybean) have been studied. Loss of lipase activity induced by the nucleophile is greater with methanol than with ethanol, and is greater for Lipozyme® TL IM than for Novozym® 435. The optimum volume of ethanol depends on the loading of solid biocatalyst and is higher for preparations of Novozym® 435 than for Lipozyme® TL IM. Maximum rates were obtained with Lipozyme® TL IM, for a molar ratio of alcohol to FA residues of 0.33. By contrast, Novozym® 435 requires at least a 2:1 ratio. Alcoholysis of the vegetable oils is faster with Lipozyme® TL IM than with Novozym® 435. Use of a high loading of Novozym® 435 (50% w/w) and a large molar excess of ethanol are required to obtain an initial rate similar to that obtained with Lipozyme® TL IM at a lower enzyme loading (10% w/w) and an equimolar ratio of ethanol and FA residues. Novozym® 435 produces quantitative conversions in only 7 h at 25 °C, but complete conversions are not obtained with Lipozyme® TL IM. Three stage stepwise addition of ethanol yields 84% conversion to ethyl esters for Lipozyme® TL IM. Hence use of Novozym® 435 is preferred. After nine cycles in a batch reactor Novozym® 435 retained 85% of its initial activity.

08/01231 Energy and economic analysis of traditional versus introduced crops cultivation in the mountains of the Indian Himalayas: a case study

Nautiyal, S. *et al. Energy*, 2007, 32, (12), 2321–2335.

This study analysed the energy and economics associated with cultivation of traditional and introduced crops in the mountains of the Central Himalaya, India. The production cost in terms of energy for introduced crops such as tomato (*Lycopersicon esculentum*) and bell pepper (*Capsicum annuum*) cultivation was 90,358–320,516 MJ ha^{-1} as compared to between 19,814 and 42,380 MJ ha^{-1} for traditional crops within Himalayan agroecosystems. For the introduced crops, high energy and monetary input was associated with human labour, forest resources, chemical fertilizer and pesticides. However, energy threshold/projection for farmyard manure in traditional crop cultivation was 80–90% of the total energy cost, thus traditional crop cultivation was more efficient in energy and economics. During the study, the farm productivity of introduced crops cultivation declined with increasing years of cultivation. Consequently, the energy output from the system has been declining at the rate of $-y20{,}598$ to $y20{,}748$ MJ $ha^{-1}\,yr^{-1}$ for tomato and $y12{,}072$ to $y15{,}056$ MJ $ha^{-1}\,yr^{-1}$ for bell pepper under irrigated and rain-fed land use in the mountains, respectively. The comparative analysis on this paradigm shift indicates that more research is needed to support sustainable crop cultivation in the fragile Himalayan environment.

08/01232 Energy use analysis of selected palm-kernel oil mills in south western Nigeria

Jekayinfa, S. O. and Bamgboye, A. I. *Energy*, 2008, 33, (1), 81–90.

Energy use patterns and utilization efficiencies in 40 factories producing palm kernel oil (PKO) in southwestern part of Nigeria were studied. The factories were stratified into small, medium and large scale categories based on the mode of operations and production capacities. Questionnaires were administered on the factories to obtain historical data on petrol, diesel and electricity consumption and PKO production outputs for seven years (1998–2004). Energy use efficiency indicators employed include: energy intensity, energy cost per unit product, energy ratio, food energy ratio and percentage oil yield by weight. Results of the study indicated that averagely, 0.58, 0.53 and 0.74 GJ/10^3 l of PKO were needed in the small, medium and large PKO factories, respectively. The average food energy ratios in the small, medium and large mills are 2.48, 2.53 and 2.14, respectively. The corresponding values of PKO conversion ratio are 0.43, 0.50 and 0.35. Electrical energy consumption in medium and large mills was lower than thermal energy due to irregularity and decline in electricity supply from the national grid. The results of the study has provided required baseline information needed for budgeting, comparison of yearly energy consumption, forecasting energy requirements and planning expansion in PKO factories.

08/01233 Enhanced hydrogen production from biomass with in situ carbon dioxide capture using calcium oxide sorbents

Florin, N. H. and Harris, A. T. *Chemical Engineering Science*, 2008, 63, (2), 287–316.

The steam gasification of biomass, in the presence of a calcium oxide (CaO) sorbent for carbon dioxide (CO_2) capture, is a promising pathway for the renewable and sustainable production of hydrogen (H_2). This work demonstrates the potential of using a CaO sorbent to enhance hydrogen output from biomass gasifiers. It also shows that CaO materials are the most suitable sorbents reported in the literature for *in situ* CO_2 capture. A further advantage of the coupled gasification-CO_2 capture process is the production of a concentrated stream of CO_2 as a byproduct. The integration of CO_2 sequestration technology with H_2 production from biomass could potentially result in the net removal of CO_2 from the atmosphere. Maximum experimental H_2 concentrations reported for the steam gasification of biomass, without CO_2 capture, range between 40%-vol and 50%-vol. When CaO is used to remove CO_2 from the product gas, as soon as it is formed, an increase in the H_2 concentrations from 40%-vol to 80%-vol (dry basis) is predicted, based on thermodynamic modelling and previously published data. The authors examine the effect of key variables, with a specific focus on obtaining fundamental data relevant to the design and scale-up of novel biomass reactors. These included: (i) reaction temperature, (ii) pressure, (iii) steam-to-biomass ratio, (iv) residence time, and (v) CO_2 sorbent loading. The authors reported on operational challenges related to *in situ* CO_2 capture using CaO-based sorbents. These included: (i) sorbent durability, (ii) limits to the maximum achievable conversion and (iii) decay in reactivity through multiple capture and release cycles. Strategies for enhancing the multicycle reactivity of CaO were reviewed, including: (i) optimized calcination conditions, and (ii) sorbent hydration procedures for reactivation of spent CaO. However, no CaO-based CO_2 sorbent, with demonstrated high reactivity, maintained through multiple CO_2 capture and release cycles, has been identified in the literature. Thus, the authors argue that the development of a CO_2 sorbent, which is resistant to physical deterioration and maintains high chemical reactivity through multiple CO_2 capture and release cycles, is the limiting step in the scale-up and commercial operation of the coupled gasification-CO_2 capture process.

08/01234 Estimated environmental loads of alpha-amylase from transgenic high-amylase maize

Wolt, J. D. and Karaman, S. *Biomass and Bioenergy*, 2007, 31, (11–12), 831–835.

Environmental exposure of plants bioengineered to improve efficiencies of biofuel production is an important consideration for their adoption. High-amylase maize genetically engineered to produce thermostable alpha-amylase in seed endosperm is currently in development, and its successful adoption will entail $>1000\,km^2$ of annual production in the USA. Environmental exposure of thermostable amylase will occur in production fields from preharvest and harvest dropped grain, with minor additional contributions from stover and root biomass. Mass loadings of thermostable alpha-amylase are projected to be $16\,kg\,km^{-2}$ and represent a potential source of increased alpha-amylase activity in receiving soils. An understanding of the degradation, persistence, accumulation, and activity of thermostable alpha-amylase introduced from transgenic high-amylase maize will be necessary in order to effectively manage transgenic crop systems intended or biofeedstock production.

08/01235 Farmer willingness to grow switchgrass for energy production

Jensen, K. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 773–781.

A survey of Tennessee farmers was conducted to analyse their willingness to supply switchgrass to an emerging energy market. The majority of respondents had not heard of growing switchgrass for energy production and roughly half were unsure as to whether they would be willing to grow switchgrass. For those with an opinion about whether they would grow switchgrass, a two limit Tobit model was used to ascertain the effects of various farm and producer characteristics on the share of farmland they would be willing to convert. Higher net farm income per hectare had a negative influence on share, reflecting the opportunity cost of converting land. Younger farmers with higher levels of educational attainment and off-farm incomes were willing to convert a higher share of farmland. Farm size and the use of leased farmland had a negative influence on willingness to convert hectares to switchgrass production. Interestingly, while erosion issues did not appear to influence share, desire to provide wildlife habitat did. Views about on-farm issues, such as market development, use of contracts, or potential harvest limitations under the Conservation Reserve Program influenced conversion share. However, views on broader national policy issues did not significantly influence farmer willingness to convert farmland.

08/01236 Fast pyrolysis of cassava rhizome in the presence of catalysts

Pattiya, A. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 72–79.

Cassava rhizome was catalytically pyrolysed at 500 °C using analytical pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) in order to investigate the effect of catalysts on bio-oil properties. The catalysts studied were zeolite ZSM-5, two aluminosilicate mesoporous materials Al-MCM-41 and Al-MSU-F, and a proprietary commercial catalyst alumina-stabilized ceria MI-575. The influence of catalysts on pyrolysis products was observed through the yields of aromatic hydrocarbons, phenols, lignin-derived compounds, carbonyls, methanol and acetic acid. Results showed that all the catalysts produced aromatic hydrocarbons and reduced oxygenated lignin derivatives, thus indicating an improvement of bio-oil heating value and viscosity. Among the catalysts, ZSM-5 was the most active to all the changes in pyrolysis products. In addition, all the catalysts with the exception of MI-575 enhanced the formation of acetic acid. This is clearly a disadvantage with respect to the level of pH in the liquid bio-fuel.

08/01237 Fuel quality changes during seasonal storage of compacted logging residues and young trees

Pettersson, M. and Nordfjell, T. *Biomass and Bioenergy*, 2007, 31, (11–12), 782–792.

Forest fuel procurement creates logistical problems, as large stocks are accumulated along the supply chain. The purpose of this study was to examine fuel quality (moisture content, ash content and calorific value) of compacted young trees (mainly downy birch) and both uncompacted and compacted logging residues (LR) (mainly Norway spruce). The materials were examined before and after storage, with and without cover, and effects of handling were considered. Dry matter losses from compacted LR during storage and handling were determined. Fuel quality and mass were determined before and after storage and handling. The moisture content of LR dropped to 28.6% when stored in small piles after fuel adapted logging at the clear felling site for 3 weeks in May. Drying continued after compaction into cylindrical bales (length 3.4 m, diameter 0.7 m) and during storage in windrows (9 and 12 months), the moisture content falling to 18.2–20.7% for the covered and 18.8–24.9% for the uncovered material. The windrow of loose LR remoistened to 40.8% (by snow contamination) resulted in a 6% lower net calorific value as received, compared to cylindrical bales. Ash contents were in the range 1.6–2.2% for LR and 1.0–1.2% for young trees. Dry matter losses ranged from 8.4% to 18.1% on compacted LR. Remoistening during the winter is higher for loose than for compacted LR. Early summer in northern Sweden provides favourable conditions for drying forest fuels.

08/01238 How to model different socio-economic and environmental aspects of biomass utilisation: case study in selected regions in Slovenia and Croatia

Krajnc, N. and Domac, J. *Energy Policy*, 2007, 35, (12), 6010–6020.

Wood biomass is an important renewable source of energy, especially in countries with traditional dependency on forestry resources. In these countries, wood biomass can have numerous positive socio-economical and environmental effects. This paper presents a new model (SCORE model) for estimation of 15 socio-economic and environmental aspects of increased use of biomass from the forests. The presented model enables selected estimation of different aspects in the whole chain of biomass production, preparation and use. Namely, the model enables the estimation of net labour income, net profit, regional public finance income, net direct jobs, net indirect jobs, net induced jobs, total net jobs, contribution to forest management, impact on wood waste utilization, impact on other woody biomass utilization, avoided costs of landfill, saving CO_2 emissions, possible impact on regional unemployment, avoided costs of unemployment, additional jobs for farmers, additional activities on farms (from indirect and induced jobs) and self-sufficiency in electricity production. The SCORE model was tested in selected regions in Slovenia and Croatia and apart from a good understanding of the socio-economic and environmental aspects, it also enables an overview of the economy of wood biomass production, given that it includes the economic analysis of wood biomass production and use. The model is not intended for a detailed economic analysis of separate phases of wood biomass production, processing and use, but particularly to show advantages or disadvantages that can result from planned and existing biomass systems.

08/01239 Impacts of biodiesel production on Croatian economy

Kulišić, B. *et al. Energy Policy*, 2007, 35, (12), 6036–6045.

The aim of this paper is to assess the direct and indirect impacts on a national economy from biodiesel (rapeseed methyl ester) production using input–output (I–O) analysis. Biodiesel development in Croatia is used as a case study. For Croatia, as for many other countries in Europe, biodiesel is a new activity not included in the existing I–O sectoral accounts. For this reason the I–O table has to be modified accordingly before being able to quantify the effect of an exogenous demand for biodiesel. Impacts in terms of output, income and employment lead to the conclusion that biodiesel production could have significant positive net impact on the Croatian economy despite the high level of subsidies for rapeseed growing.

08/01240 Increased yields in biodiesel production from used cooking oils by a two step process: comparison with one step process by using TGA

Çayli, G. and Küsefoğlu, S. *Fuel Processing Technology*, 2008, 89, (2), 118–122.

Short chain alcohol esters of fatty acids can be used as diesel fuel. In this study, one step and two step base catalysed room temperature transesterification reaction of used cooking oil was compared. In the two step base catalysed process, for 1000 g of used cooking oil 4.2 g NaOH and 140 ml MeOH was used in the first step and 1.8 g NaOH and 60 ml MeOH was used in the second step. All reactions were done at 25 °C; th7e effects of water content and suspended particles on the yield were studied. The yields were easily determined by thermo gravimetric analysis instead of the usual gas chromatography and the viscosity of products was measured by Ubbelohde type viscosimeter. It was found that two step processes gives a better yield (96%) than the one step process (86%).

08/01241 Influence of torrefaction on the grindability and reactivity of woody biomass

Arias, B. *et al. Fuel Processing Technology*, 2008, 89, (2), 169–175.

The use of biomass to produce energy is becoming more and more frequent as it helps to achieve a sustainable environmental scenario. However the exploitation of this fuel source does have drawbacks that need to be solved. In this work, the torrefaction of woody biomass (eucalyptus) was studied in order to improve its properties for pulverized systems. The process consisted in a heating treatment at moderate temperature (240, 260, 280 °C) under an inert atmosphere. The grindability of raw biomass and the treated samples was compared and an improvement in the grindability characteristics was observed after the torrefaction process. Thermogravimetric analysis of the samples was carried out in order to study their reactivity in air. The DTG curves of the torrefied biomass showed a double peak nature. The kinetic parameters were calculated for each reaction stage. The torrefaction process was found to influence the parameters of the first stage, whereas those corresponding to the second remained unaffected.

08/01242 Jute stick pyrolysis for bio-oil production in fluidized bed reactor

Asadullah, M. *et al. Bioresource Technology*, 2008, 99, (1), 44–50.

Pyrolysis of jute stick for bio-oil production has been investigated in a continuous feeding fluidized bed reactor at different temperatures ranging from 300 to 600 °C. At 500 °C, the yields of bio-oil, char and non-condensable gas were 66.70 wt%, 22.60 wt% and 10.70 wt%, respectively based on jute stick. The carbon based non-condensable gas was the mixture of carbon monoxide, carbon dioxide, methane, ethane, ethene, propane and propene. The density and viscosity of bio-oil were found to be 1.11 g/mL and 2.34 cP, respectively. The lower heating value (LHV) of bio-oil was found to be 18.25 MJ/kg. Since bio-oil contains some organic acids such as formic acid, acetic acid, etc., the pH and acid value of the bio-oil were found to be around 4 and 135 mg KOH/g, respectively. The water, lignin, solid and ash contents of bio-oil were determined and found to be around 15 wt%, 4.90 wt%, 0.02 wt% and 0.10 wt%, respectively.

08/01243 Maximizing renewable hydrogen production from biomass in a bio/catalytic refinery

Westermann, P. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4135–4141.

Biological production of hydrogen from biomass by fermentative or photofermentative microorganisms has been described in numerous research articles and reviews. The major challenge of these techniques is the low yield from fermentative production, and the large reactor volumes necessary for photofermentative production. Due to these constraints biological hydrogen production from biomass has so far not been considered a significant source in most scenarios of a future hydrogen-based economy. In this review the current state of art of biomass-based hydrogen production is briefly summarized and a combination of a biorefinery suggested for the production of multiple fuels (hydrogen, ethanol, and methane) and chemical catalytic technologies which could lead to a yield of 10–12 mol hydrogen per mol glucose derived from biological waste products. Besides the high hydrogen yield, the advantage of the suggested concept is the high versatility with respect to input of different types of biological wastes, which are abundant and cheap residues from agricultural production. Also the concept leaves the opportunity to optimize the microbiological and catalytic processes to meet specific needs for fuel flexibility.

08/01244 Modeling and analysis of a fan–pad ventilated floricultural greenhouse

Ganguly, A. and Ghosh, S. *Energy and Buildings*, 2007, 39, (10), 1092–1097.

The application of greenhouse technology in the field of floriculture is rapidly expanding worldwide. In India solar radiation is abundant and the climate in the plains are rather hot and dry in summer months while the coastal parts witness a hot and humid climate. For greenhouses in such climates, cooling and ventilation are major factors influencing the production of quality flowers. In the present paper a thermal model of a greenhouse is presented based on fan–pad evaporative cooling. Thermal performance of the greenhouse, as predicted by the model under different climatic conditions is analysed and compared with a reference study available in the literature. The analysis reveals that a suitable combination of evaporative cooling, shading and ventilation arrangements can effectively maintain the inside microclimate of the greenhouse within permissible limits throughout the year.

08/01245 Modelling and experimental studies on pyrolysis of biomass particles

Sadhukhan, A. K. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (2), 183–192.

A simple mathematical model has been developed to describe the pyrolysis of a single biomass particle. A fully transient analysis involving a kinetic model coupled with heat transfer model has been presented. The kinetic model consists of both primary and secondary pyrolysis reactions while the heat transfer model includes diffusive, convective and radiative modes of heat transfer. Fourth-order Runge–Kutta–Gill method is used to solve the kinetic model, while implicit finite volume method with tri-diagonal matrix algorithm is employed to solve the heat transfer model. The kinetic parameters and heat of reaction are estimated by Levenberg Marquardt nonlinear optimization technique. A general-purpose FORTRAN program is developed to solve the model equations and estimation of parameters. Experimental investigations are carried out for wood fines and cylinders in an electrically heated reactor. The model predictions for temperature and mass loss histories are in excellent agreement with the experimental results. The model is also validated with published experimental results. Finally, the effects of temperature and particle size on pyrolysis time and yield of final char have been analysed with model simulation.

08/01246 Potential bioethanol and biogas production using lignocellulosic biomass from winter rye, oilseed rape and faba bean

Petersson, A. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 812–819.

To meet the increasing need for bioenergy several raw materials have to be considered for the production of e.g. bioethanol and biogas. In this study, three lignocellulosic raw materials were studied, i.e. (1) winter rye straw (*Secale cereale* L), (2) oilseed rape straw (*Brassica napus* L.) and (3) faba bean straw (*Viciafaba* L.). Their composition with regard to cellulose, hemicellulose, lignin, extractives and ash was evaluated, as well as their potential as raw materials for ethanol and biogas production. The materials were pretreated by wet oxidation using parameters previously found to be optimal for pretreatment of corn stover (195 °C, 15 min, 2 g l^{-1} Na_2CO_3 and 12 bar oxygen). It was shown that pretreatment was necessary for ethanol production from all raw materials and gave increased biogas yield from winter rye straw. Neither biogas productivity nor yield from oilseed rape straw or faba bean straw was significantly affected by pretreatment. Ethanol was produced by the yeast *Saccharomyces cerevisiae* during simultaneous enzymatic hydrolysis of the solid material after wet oxidation with yields of 66%, 70% and 52% of theoretical for winter rye, oilseed rape and faba bean straw, respectively. Methane was produced with yields of 0.36, 0.42 and 0.44 l g^{-1} volatile solids for winter rye, oilseed rape and faba bean straw, respectively, without pretreatment of the materials. However, biogas productivity was low and it took over 50 days to reach the final yield. It could be concluded that all three materials are possible raw materials for either biogas or ethanol production; however, improvement of biogas productivity or ethanol yield is necessary before an economical process can be achieved.

08/01247 Predicting charring rate of woods exposed to time-increasing and constant heat fluxes

Yang, L. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 1–6.

This paper describes an investigation of the charring of wood exposed to a time-increasing heat flux and constant heat fluxes by using a modified partial differential equation model, whose calculated result is validated by experimental result under time-increasing heat fluxes. It is assumed that the base of the char layer can be defined by the temperature of 300 °C. The results have shown that the rate of increase of heat flux and the density of woods significantly affect the charring rate and the charring rate of woods under time-increasing heat fluxes is smaller than that exposed to a constant heat flux. Linear regression conducted on the predictions of charring depth with time as the dependent time-increasing was suitable for time-increasing heat fluxes, while power regression was more suitable for constant heat flux. A successful experiential expression, which describing the relationship among char rate of woods and the increasing rate of heat fluxes and density of wood, has been suggested under time-increasing heat fluxes.

08/01248 Risk analysis of a biomass combustion process using MOSAR and FMEA methods

Thivel, P.-X. *et al. Journal of Hazardous Materials* , 2008, 151, (1), 221–231.

Thermal and chemical conversion processes that convert in energy the sewage sludge, pasty waste and other pre-processed waste are increasingly common, for economic and ecological reasons. Fluidized bed combustion is currently one of the most promising methods of energy conversion, since it burns biomass very efficiently, and produces only very small quantities of sulfur and nitrogen oxides. The hazards associated with biomass combustion processes are fire, explosion and poisoning from the combustion gases (CO, etc.). The risk analysis presented in this paper uses the MADS–MOSAR methodology, applied to a semi-industrial pilot scheme comprising a fluidization column, a conventional cyclone, two natural gas burners and a continuous supply of biomass. The methodology uses a generic approach, with an initial macroscopic stage where hazard sources are identified, scenarios for undesired events are recognized and ranked using a grid of Severity × Probability and safety barriers suggested. A microscopic stage then analyses in detail the major risks identified during the first stage. This analysis may use various different tools, such as HAZOP, FMEA, etc.: the analysis is based on FMEA. Using MOSAR, five subsystems were identified: the reactor (fluidized bed and centrifuge), the fuel and biomass supply lines, the operator and the environment. When the authors drew up scenarios based on these subsystems, malfunction of the gas supply burners was found to be a common trigger in many scenarios. The subsequent microscopic analysis, therefore, focused on the burners, looking at the ways they failed, and at the effects and criticality of those failures (FMEA). The authors were, thus, able to identify a number of critical factors such as the incoming gas lines and the ignition electrode.

08/01249 Socio-economic impacts of energy crops for heat generation in Northern Greece

Panoutsou, V. *Energy Policy*, 2007, 35, (12), 6046–6059.
Bioenergy is considered to be an attractive option mainly due to driving forces of an environmental nature (e.g. climate change and sustainability issues). This is particularly the case for energy crops, which show higher productivity per land unit than their conventional counterparts. In addition, by comparison, such crops are more homogeneous in terms of their physical and chemical characteristics than residual resources that are often described as the biomass resource of the future. However, despite the long-term research and the considerable efforts to promote them, implementation is still rather slow across Europe. In this paper, two perennial energy crops, cardoon and giant reed, are evaluated in Rodopi, northern Greece, as alternative land use, through comparative financial appraisal with the main conventional crops. Based on the output of this analysis, the breakeven for the two energy crops is defined and an economic and socio-economic evaluation of a biomass district heating system is conducted. Results prove that energy crops can be attractive alternatives if they are properly integrated into existing agricultural activities and complement the current cropping options. As such, they provide raw material for local heat applications, thus resulting in increased income for the region and an increase in the number of jobs.

08/01250 Supply of biomass, bioenergy, and carbon mitigation: method and application

Gan, J. *Energy Policy*, 2007, 35, (12), 6003–6009.
This study develops an analytical framework for deriving the supply of biomass feedstock and subsequently electricity and CO_2 displacement generated from the biomass. This systematic approach minimizes the total cost of both feedstock and electricity production and involves the determination of the optimal power plant size and the derivation of the supply curves. The analytical framework is applied to the case of logging residues in the USA. Both the theoretical and empirical results point to the importance of simultaneously considering feedstock production, energy conversion, and environmental benefits/costs in bioenergy project development, leading to useful policy implications for bioenergy development and deployment.

08/01251 The effects of digestion temperature and temperature shock on the biogas yields from the mesophilic anaerobic digestion of swine manure

Chae, K. J. *et al. Bioresource Technology*, 2008, 99, (1), 1–6.
In order to obtain basic design criteria for anaerobic digesters of swine manure, the effects of different digesting temperatures, temperature shocks and feed loads, on the biogas yields and methane content were evaluated. The digester temperatures were set at 25, 30 and 35 °C, with four feed loads of 5%, 10%, 20% and 40% (feed volume/digester volume). At a temperature of 30 °C, the methane yield was reduced by only 3% compared to 35 °C, while a 17.4% reduction was observed when the digestion was performed at 25 °C. Ultimate methane yields of 327, 389 and 403 mL CH_4/g VS_{added} were obtained at 25, 30 and 35 °C, respectively; with moderate feed loads from 5% to 20% (V/V). From the elemental analysis of swine manure, the theoretical biogas and methane yields at standard temperature and pressure were 1.12 L biogas/g $VS_{destroyed}$ and 0.724 L CH_4/g $VS_{destroyed}$, respectively. Also, the methane content increased with increasing digestion temperatures, but only to a small degree. Temperature shocks from 35 to 30 °C and again from 30 to 32 °C led to a decrease in the biogas production rate, but it rapidly resumed the value of the control reactor. In addition, no lasting damage was observed for the digestion performance, once it had recovered.

08/01252 Theoretical study on the reaction route for the major liquid product from pyrolysis of triethylamine

Wang, Z. and Lin, R. *Journal of Analytical and Applied Pyrolysis*, 2008, 81, (2), 205–210.
Triethylamine can work as an initiator for promoting the cracking of heptane, and the mechanism study helps to understand the initiating effect. While, the components in liquid product can hardly be purely separated for further analysis. In this paper, two compounds are found of well matching a same mass spectrum, so the liquid product by the pyrolysis of triethylamine is further determined by Gaussian 98. It is found that *N*,*N*-diethyl radical is the most stable intermediate during the homologous pyrolysis process. The energies of two transition-states of two possible reaction routes from *N*,*N*-diethyl radical are compared, through which the reaction route is clarified and the liquid product is identified as *N*-ethylidene-ethanamine.

Geothermal energy

08/01253 Evaluation of the suitability of a fixed speed wind turbine for large scale wind farms considering the new UK grid code

El-Helw, H. M. and Tennakoon, S. B. *Renewable Energy*, 2008, 33, (1), 1–12.
The analysis of the reactive power management of a wind farm consisting of fixed speed wind turbines is carried out. The rating calculation of the compensator for a fixed speed wind farm is evaluated, and the effect of the network strength on the compensator rating is studied. Also the compatibility of fixed speed wind turbine with the new UK grid code requirements is evaluated by simulation using Matlab/Simulink. The simulation results show that the compensator rating is mainly determined by the need to meet the grid code specifications, rather than the steady state reactive power capability obligation. The main conclusion is that a fixed speed wind farm based on simple induction generators is unable to meet the new grid code requirements, unless the compensator rating is increased substantially.

08/01254 Fourier analysis of short-period water level variations in the Rotorua geothermal field, New Zealand

Leaver, J. D. and Unsworth, C. P. *Geothermics*, 2007, 36, (6), 539–557.
The results of a Fourier analysis of water level measurements recorded near the nationally significant Pohutu Geyser in New Zealand are reported. Their analysis clearly identifies periodic pressure variations induced by barometric, gravity, thermal, anthropogenic and subsurface disturbing influences, which can be used as a benchmark for identifying and quantifying detrimental changes in behaviour. A report is given on the performance of Fourier analysis on synthetically generated signals with different levels of white noise and discrete impulses. The authors were able to attribute periodic variations to various disturbing effects and quantify the magnitude of these changes. Diurnal and semi-diurnal variations for both anthropogenic and barometric disturbing influences are shown to have amplitudes in the range 2.8–5.2 mm-H_2O while earth tidal amplitudes are less than 1 mm-H_2O.

08/01255 Geothermal energy use in hydrogen liquefaction

Kanoglu, M. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4250–4257.
The use of geothermal energy for hydrogen liquefaction was proposed and three possible cases investigated for accomplishing such a task including (1) using geothermal output work as the input for a liquefaction cycle; (2) using geothermal heat in an absorption refrigeration process to precool the gas before the gas is liquefied in a liquefaction cycle; and (3) using part of the geothermal heat for absorption refrigeration to precool the gas and part of the geothermal heat to produce work and use it in a liquefaction cycle (i.e. cogeneration). A binary geothermal power plant is considered for power production while the precooled Linde–Hampson cycle is considered for hydrogen liquefaction. A liquid geothermal resource is considered and both ideal (i.e. reversible) and non-ideal (e.g. irreversible) system operations are analysed. A procedure for such an investigation is developed and appropriate performance parameters are defined. Also, the effects of geothermal water temperature and gas precooling temperature on system performance parameters are studied. The results show that there is a significant amount of energy savings potential in the liquefaction work requirement as a result of precooling the gas in a geothermal absorption cooling system. Using geothermal energy in a cogeneration scheme (power production and absorption cooling) also provides significant advantages over the use of geothermal energy for power production only.

08/01256 In-service testing of wind turbine towers using a microwave sensor

Pieraccini, M. *et al. Renewable Energy*, 2008, 33, (1), 13–21.
A remote-sensing technique based on microwave interferometry is applied to dynamic testing of wind turbine towers for power generation. A high-speed interferometric radar is able to sample the structure at a rate high enough for modal and transient analysis. An experimental campaign is reported carried out on wind turbine towers of a power plant in north Sardinia, Italy.

08/01257 Multi-isotopic (Li, B, Sr, Nd) approach for geothermal reservoir characterization in the Limagne Basin (Massif Central, France)

Millot, R. *et al. Applied Geochemistry*, 2007, 22, (11), 2307–2325.
A multi-isotopic study of thermo-mineral waters from the Limagne Basin (French Massif Central) is reported. Lithium, B, Sr and Nd isotopic signatures in thermo-mineral waters and bedrocks were combined in order to determine the origin of these fluids from a reservoir point of view. Strontium and Nd isotopic systems showed that the thermo-mineral waters are mostly derived from a granitic reservoir

type, with the exception of a few water samples having Sr and Nd isotopic signatures also reflecting a volcanic contribution (basalts). In a second step, Li and B isotopes were investigated, given that Li and B isotopic systematics are potentially affected by mass dependent fractionation during water/rock interaction and could provide some information on what takes place during this process. A great diversity of thermo-mineral waters within the Aigueperse area was clearly observed, which is directly related to the origin of these thermal waters in terms of reservoirs. These different geothermal reservoirs are characterized by different geological settings and intensity of water/rock interaction (i.e. depth and temperature). The combination of Li, B, Sr and Nd isotopic systems highlight the complexity of the study of these geothermal reservoirs and that the use of only one isotopic tool could lead to an incomplete interpretation of the origin of water. The new approach using Li isotopes shows a very interesting potential with additional information on the intensity of water/rock interaction.

08/01258 Three-dimensional imaging of a geothermal system using temperature and geological models derived from a well-log dataset

Teng, Y. and Koike, K. *Geothermics*, 2007, 36, (6), 518–538.

The accurate imaging of geothermal systems from the ground surface down to great depths is an interdisciplinary problem common to geothermal resource exploration and development. Rocks can be characterized mainly in terms of their lithology, mineralogy, fracture distribution, permeability, thermal conductivity and porosity, and similarly the geothermal fluid (and its circulation) by its geochemistry, flow pattern, velocity, temperature and pressure. Some of these data are obtained by well logging and from laboratory tests conducted on drillhole cores. In general, the distribution of geothermal wells is not random, and well data are limited in terms of quantity and depth range. Accordingly, a sophisticated spatial modelling technique is indispensable in the three-dimensional imaging of geothermal systems. A versatile 3-D modelling method is described that can be used to determine the temperature, flow velocity, and distribution of geological units within a geothermal field based on well log data. The model results for the Hohi geothermal area, Japan, provide plausible estimates of temperature, flow velocity, and geology to a depth of 3000 m. Superimposition of the three spatial models that were obtained shows that, at Hohi, two geothermal reservoirs are localized near highly fractured fault zones that provide paths for the ascent of thermal fluids from depth.

Solar energy

08/01259 A detailed modeling method for photovoltaic cells

Chenni, R. *et al. Energy*, 2007, 32, (9), 1724–1730.

The photovoltaic cells current–voltage mathematical description is usually defined by a coupled non-linear equation, difficult to solve using analytical methods. This paper investigates a modelling process configuring a computer simulation model, able to demonstrate the cell's output features in terms of irradiance and temperature environment changes. The model is based on four parameters, and it is tested to simulate three popular types of photovoltaic panels constructed with different materials: copper indium diselenide thin film, multi-crystalline silicon, and mono-crystalline silicon. A comparative study of simulation results, carried out by the product manufacturer data, is provided to prove the efficiency of the proposed approach.

08/01260 Advances on multi-purpose solar adsorption systems for domestic refrigeration and water heating

Alghoul, M. A. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 813–822.

In this paper a review of the multi purpose solar adsorption systems is presented. Single solar adsorption system is normally designed for use as a refrigerator. Solar adsorption system can also be designed for dual purpose – as a refrigerator and a water heater. The system can also be operated intermittently or continuously. In intermittent operation the cooling process takes place at night while in a continuous operation the process takes place in the day as well as at night. The various design of the solar adsorption systems reported in the literature thus far is presented. The authors begin by giving information on the vital components that make up the adsorption system.

08/01261 Annual performance analysis and thermal modelling of passive solar still for different inclinations of condensing cover

Tiwari, A. K. and Tiwari, G. N. *International Journal of Energy Research*, 2007, 31, (14), 1358–1382.

This paper reports the annual as well as seasonal performance analysis of single-slope passive solar stills having three different inclinations of condensing cover, namely 15, 30 and 45°. The analysis is based on the experiments conducted throughout the year from June 2004 to May 2005 on one clear day every month. Each experiment has been carried over for 24 h for the New Delhi (latitude: 28°37′ north and longitude: 77°13′ east) climatic conditions. It was observed that the 15° inclination of condensing cover gives maximum annual yield and distillation efficiency. The concept of solar fraction has been used for the validation of thermal modelling. The fair agreement has been noted between the values observed experimentally and calculated theoretically for temperatures and yield in all seasons.

08/01262 Calculation of the horizon brightness irradiance in the model of Perez using the unit-sphere method

Torres, J. L. *et al. Renewable Energy*, 2008, 33, (1), 149–154.

The present technical note describes a computer tool for determining the horizon brightness diffuse irradiance on a tilted plane in the model of Perez. The applied procedure considers the configuration factor concept, which is calculated using the unit-sphere method. The results obtained with this procedure, which is more exact than the one followed by Perez, are compared with the ones obtained with Perez's proposal. It may be observed that for small angles of inclination differences are up to 36%, and that said differences decrease when the angle of inclination increases. For angles higher than 77.15°, differences become lower than 1%. It may be concluded that the described procedure, together with the computer tool for implementing it, is adequate for determining the horizon brightness irradiance on a tilted plane, once the radiance of this area of the sky dome is known.

08/01263 CDM potential of SPV pumps in India

Purohit, P. and Michaelowa, A. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 181–199.

So far, the cumulative number of renewable energy systems such as solar photovoltaic (SPV) irrigation pumps in the agriculture sector in India is far below their theoretical potential despite government subsidy programmes. One of the major barriers is the high costs of investments in these systems. The clean development mechanism (CDM) provides industrialized countries with an incentive to invest in emission reduction projects in developing countries to achieve a reduction in CO_2 emissions at lowest cost that also promotes sustainable development in the host country. SPV pumps could be of interest under the CDM because they directly displace greenhouse gas emissions while contributing to sustainable rural development. However, there is only one SPV project under the CDM so far. This study assesses the maximum theoretical as well as the realistically achievable CDM potential of SPV pumps in India. Due to mitigation costs of 24–242 € per ton CO_2 at current CER prices of less than 15 €, SPV pump projects are not viable. However, substitution of diesel pumps could be made viable by a relatively limited subsidy. While the maximum mitigation volume is more than 214 million ton CO_2 on an annual basis, an estimate of achievable CER levels is done using the past diffusion trends of SPV pumps. It is found that annual CER volumes could reach 50,000–100,000 by 2012 and 0.25–0.75 million by 2020. This would require that the government sets the subsidy level for SPV pumps at a level that allows them to become viable with the CER revenue. From a macro-economic point of view this makes sense if the sustainability benefits are deemed sufficiently high to warrant promotion of this project type.

08/01264 Computational study of a novel continuous solar adsorption chiller: performance prediction and adsorbent selection

Voyiatzis, E. *et al. International Journal of Energy Research*, 2007, 31, (10), 931–946.

A novel solar adsorption chiller intended for domestic use is presented. The chiller can be integrated with existing solar systems based on flat plate collectors, and, contrary to commercial chillers, it operates continuously. A detailed analysis of both the simple and the heat-integrated cycle is carried out so as to select the optimal adsorbent and operating conditions. The employed integral thermodynamic model takes into account the inert masses that limit the performance of the chiller, such as the metal frame, the thermofluid, and the non-adsorbed steam, by introducing heat capacity effects. Given the adsorption equilibrium data, the energy balances, the performance, and the useful thermal loads of the system can be calculated at any operating conditions. The results indicate that silica gel Type A is a more efficient adsorbent compared to silica gel Type RD or Type 3A. Furthermore, the total porosity has a slight effect on system performance, while optimal operation can be achieved when the condenser temperature is less than 326 K and the evaporator temperature greater than 280 K.

08/01265 Deposition pressure effects on material structure and performance of micromorph tandem solar cells

Veneri, P. D. *et al. Renewable Energy*, 2008, 33, (1), 42–47.

Tandem solar cells represent an elegant way of overcoming the efficiency limits of single-junction solar cells and reducing the light-induced degradation of amorphous silicon films. Stacked structures consisting of an amorphous silicon top cell and a microcrystalline silicon bottom cell allow a good utilization of the solar spectrum due to the band gap values of the two materials. These devices, firstly introduced by the IMT research group, were designated as 'micromorph' tandem solar cells. To better exploit this concept, it is important to tune parameters like the band gaps and the short-circuit currents. In this work, the authors have realized micromorph tandem solar cells on Asahi U-type TCO-covered glass substrates. The intrinsic layer of both the amorphous top cell and the microcrystalline bottom cell is grown by very high frequency plasma enhanced chemical vapour deposition at 100 MHz at low substrate temperature (150 °C). Finally, a ZnO reflector and a metal contact complete the structure. No intermediate optical mirror between the two cells is used at this stage. Undiluted a-Si:H, with reduced band gap when compared to H_2-diluted amorphous silicon, is used as absorber layer in the top cell. As for the bottom cell, the high-pressure–high-power regime (up to 267 Pa–80 W) has been explored aiming at growing high-quality microcrystalline silicon at large deposition rates. The effect of the structural composition of the microcrystalline absorber layer on the current–voltage characteristic and spectral response of tandem devices has been investigated. An efficiency of 11.3% has been obtained with short-circuit current densities around 13 mA/cm^2, open-circuit voltages ~1.34 V and fill factors ~66%.

08/01266 Effect of energy storage medium (black granite gravel) on the performance of a solar still

Sakthivel, M. and Shanmugasundaram, S. *International Journal of Energy Research*, 2008, 32, (1), 68–82.

In this study, a detailed experiment has been conducted on a single-basin solar still which is modified with energy storage medium of black granite gravel. An attempt has been made to utilize the maximum amount of solar energy and to reduce the heat loss from the sides and bottom of the still. The conventional still is modified with an energy storage medium of black granite gravel of 6 mm size which is provided in the basin for different (quantity) depths. The black granite gravel functions as energy storage medium and also as an insulation layer to reduce the bottom and side loss coefficients. The black gravel is used for absorbing the excess heat energy from solar radiation during the noon hours. Due to this, the heat accumulated in the space between the water and glass surface is reduced and hence the temperature difference between the water and glass surfaces increases. The depth (quantity) of the gravel layer in the basin will influence the performance of the still and some of the parameters like basin temperature, water temperature, glass temperature and still productivity. This study deals with the effect of aforesaid parameters on the performance of the still. An attempt has been made to optimize the still performance for the above-mentioned parameters. A mathematical model is developed to estimate the water, gravel, and inside glass temperatures theoretically and to estimate the hourly and daily yield. To show the effectiveness of the modification, its performance is compared with the conventional still under the same climatic condition. It is found that the still yield is increased by 17–20% with almost no cost for this modification as black granite gravel is very cheap. Error analysis was done by comparing the theoretical and experimental results to show the validity of the mathematical model. It is found that the maximum percentage of discrepancy for all the parameters is about ±18%. Theoretical value of yield per day has 8% discrepancy over experimental value.

08/01267 Effect of solar radiation correlations on system sizing: PV pumping case

Yesilata, B. and Firatoglu, Z. A. *Renewable Energy*, 2008, 33, (1), 155–161.

The precise determination of solar radiation intensity is important for accurate system sizing. For PV pumping system case, the issue becomes more important since inaccurate solar radiation data nonlinearly reflected to the calculations. Inappropriate solar radiation model selection for a specific design site is a major cause for inaccurate system sizing. The differences in power output of a PV pumping system due to using some solar radiation correlations are examined here. The results are then compared with those of long-term solar radiation measurements. It is reported that the system sizing with the measurements and the most appropriate correlation for the application site significantly differ since the errors in predicting solar radiation data are nonlinearly propagated to the system power output.

08/01268 Effect of the compositional distribution on the photovoltaic power conversion of SiGe solar cells

Usami, N. *et al. Solar Energy Materials and Solar Cells*, 2007, 91, (2–3), 123–128.

Theoretical investigation on the photovoltaic power conversion of SiGe solar cells was carried out focusing on the impact of the compositional distribution. The absorption coefficient and the intrinsic carrier concentration were assumed to be macroscopically uniform parameters controlled by the compositional distribution. Under an assumption with finite minority carrier diffusion length, solar cell based on SiGe was revealed to have power conversion superior to that based on Si in a limited compositional window on the Si-rich side. In the window, the increase in the photocurrent density overcompensates the decrease in the voltage, and controls the overall conversion efficiency. The width of the window was greatly affected by the compositional distribution in SiGe. A comparison was made with experiments to support the existence of such a compositional window.

08/01269 Evaluation of a PV-integrated building application in a well-controlled outdoor test environment

Bloem, J. J. *Building and Environment*, 2008, 43, (2), 205–216.

This paper presents the assessment of experimental data for electrical and thermal performance evaluation of photovoltaic (PV) systems integrated as cladding components into the building envelope, giving input to modelling and analysis work. From the experience gained in several EU research projects, an improved design for a common Test Reference Environment (TRE) has been developed. This specific design of the PV module and TRE makes it possible to study, through electrical and thermal energy flow analysis, the effect on electrical performance of using different materials for PV modules and the construction design of claddings. The results for a glass–glass PV module with forced ventilation are presented.

08/01270 Exergetic performance analysis of a solar pond

Karakilcik, M. and Dincer, I. *International Journal of Thermal Sciences*, 2008, 47, (1), 93–102.

This paper presents an experimental and theoretical investigation of the exergetic performance of a solar pond (with a surface area of 4 m^2 and a depth of 1.5 m) which was built at Cukurova University in Adana, Turkey. The system was filled with salty water to form three zones (e.g. upper convective, non-convective and heat storage) accordingly. A data acquisition device was used to measure and record the temperatures hourly at various locations in the pond (distributed vertically within and at the bottom of the pond, and horizontally and vertically within the insulated side-walls). An exergy model is developed to study the exergetic performance of the pond and its three zones in terms of exergy efficiencies, which are then compared with the corresponding energy efficiencies. The reference environment temperature is specified for exergy analysis as the average representative temperature of each month of the year (for example, it is taken as an average temperature of 28 °C for August). Thus, the highest energy and exergy efficiencies are found for August to be: 4.22% and 3.02% for the upper convective zone, 13.80% and 12.64% for the non-convective zone, and 28.11% and 27.45% for the heat storage zone, respectively.

08/01271 Experimental and modelling performances of a roof-integrated solar drying system for drying herbs and spices

Janjai, S. *et al. Energy*, 2008, 33, (1), 91–103.

This paper presents experimental performance of solar drying of rosella flower and chili using roof-integrated solar dryer and also presents modelling of the roof-integrated solar dryer for drying of chili. Field-level tests for deep bed drying of rosella flower and chili demonstrated that drying in the roof-integrated solar dryer results in significant reduction in drying time compared to the traditional sun drying method and the dry product is a quality dry product compared to the quality products in the markets. The payback period of the roof-integrated solar dryer is about 5 years. To simulate the performance of the roof-integrated solar dryer for drying herbs and spices using hot air from roof-integrated solar collectors, two sets of equations were developed. The first set of equations was solved implicitly and the second set of equations was solved explicitly using finite difference technique. The simulated air temperatures at the collector outlet agreed well with the observed air temperatures. Good agreement was also found between experimental and simulated moisture contents.

08/01272 Improved PV/T solar collectors with heat extraction by forced or natural air circulation

Tonui, J. K. and Tripanagnostopoulos, Y. *Renewable Energy*, 2007, 32, (4), 623–637.

The photovoltaic (PV) cells suffer efficiency drop as their operating temperature increases especially under high insolation levels and cooling is beneficial. Air-cooling, either by forced or natural flow, presents a non-expensive and simple method of PV cooling and the solar preheated air could be utilized in built, industrial and agricultural sectors. However, systems with heat extraction by air circulation are limited in their thermal performance due to the low density, the small volumetric heat capacity and the small thermal conductivity of air and measures for heat transfer augmentation is necessary. This paper presents the use of a suspended thin flat metallic sheet at the middle or fins at the back wall of an air duct as heat transfer augmentations in an air-cooled photovoltaic/thermal (PV/T) solar collector to improve its overall performance. The steady-state thermal efficiencies of the modified systems are compared with those of typical PV/T air system. Daily temperature profiles of the outlet air, the PV rear surface and channel back wall are presented confirming the contribution of the modifications in increasing system electrical and thermal outputs. These techniques are anticipated to contribute towards wider applications of PV systems due to the increased overall efficiency.

08/01273 Mechanical integrity of dye-sensitized photovoltaic fibers

Ramier, J. *et al. Renewable energy*, 2008, 33, (2), 314–319.

The development of photovoltaic (PV) devices based on dye-sensitized TiO_2-coated Ti fibres has opened up exciting possibilities for novel PV textile applications. The cohesion and adhesion of the TiO_2 layer are identified as crucial factors in maintaining PV efficiency during textile manufacture and weaving operations. The present work describes a systematic investigation of the corresponding damage mechanisms and their influence on the overall PV fibre performance during mechanical deformation. The results confirm that with proper control of the tension of the weft and in the warp, high PV efficiency woven textures are feasible using this technology.

08/01274 Modeling and fault diagnosis of a photovoltaic system

Chao, K.-H. *et al. Electric Power Systems Research*, 2008, 78, (1), 97–105.

In this paper, a circuit-based simulation model of a photovoltaic (PV) panel by PSIM software package is developed, firstly. Then, a 3 kW PV arrays established by using the proposed PSIM model with series and parallel connection is not only employed to carry out the fault analysis, but also to represent its *I–V* and *P–V* characteristics at variable surface temperatures and isolations under normal operation. Finally, a novel extension diagnosis method based on the extended correlation function and the matter-element model was proposed to identify the faulting types of a 3 kW PV system. The simulated results indicate that the proposed fault diagnosis method can detect the malfunction types correctly and promptly.

08/01275 Performance of a hybrid heating system with thermal storage using shape-stabilized phase-change material plates

Zhou, G. *et al. Applied Energy*, 2007, 84, (10), 1068–1077.

Performance of a hybrid heating-system, combined with thermal storage using shape-stabilized phase-change material (SSPCM) plates, is investigated numerically. A direct gain passive solar house in Beijing is considered, which includes SSPCM plates as the inner linings of walls and the ceiling. Unsteady simulation is performed using a verified enthalpy model, with a time period covering the winter heating-season. Additional heat supply is employed during load hours at late night and early morning (23:00–07:00 in Beijing) or during the whole day necessary to keep the minimum indoor air temperature above 18 °C. The results indicate the thermal storage effect of SSPCM plates, which improves the indoor thermal comfort level and saves about 47% of normal-and-peak-hour energy use and 12% of total energy consumption in winter in Beijing.

08/01276 Quantum size effects in amorphous Si superlattice solar cells

Varonides, A. C. *Renewable energy*, 2008, 33, (2), 273–276.

Amorphous silicon/alloy superlattices provide advantages in solar cell design, such as (a) effective band gap widening (b) effective mass separation (c) increased open-circuit voltage. The latter increases via Fermi level control, due to p-doping of potential barriers, pushing EF towards the valence bands, with simultaneous widening of the effective band gap, thus leading to potentially higher collection incident wavelengths. The density of gap states in the heavily doped layer is modelled as an exponential whose parameter kT* can be varied by the doping concentrations, while its activation energy saturates at some value. This communication provides (i) a general formulation of the problem at finite temperatures as well as numerical results for specific realizable contacts (ii) detailed treatment of gap states (iii) the neutrality condition (iv) a relation between Fermi level position and open-circuit voltage in the nitride region (superlattice p-region). For a p-(a-SiN: H/a-Si: H)-i (a-Si: H)-n (a-Si: H) sample, the authors compute the Fermi level position relative to the a-Si: H valence band edge. For low and wide gap thin layers of the order of 2.5–3.5 nm, open-circuit voltage values are predicted in excess of 1.05 V, and efficiencies are predicted in excess of 12%.

08/01277 Solar integrated energy system for a green building

Zhai, X. Q. *et al. Energy and Buildings*, 2007, 39, (8), 985–993.

Shanghai is characteristic of subtropical monsoon climate with the mean annual temperature of 17.6 °C, and receives annual total radiation above 4470 MJ/m^2 with approximately 2000 h of sunshine. A solar energy system capable of heating, cooling, natural ventilation and hot water supply has been built in Shanghai Research Institute of Building Science. The system mainly contains 150 m^2 solar collector arrays, two adsorption chillers, floor radiation heating pipes, finned tube heat exchangers and a hot water storage tank of 2.5 m^3 in volume. It is used for heating in winter, cooling in summer, natural ventilation in spring and autumn, hot water supply in all the year for 460 m^2 building area. The whole system is controlled by an industrial control computer and operates automatically. Under typical weather condition of Shanghai, it is found that the average heating capacity is up to 25.04 kW in winter, the average refrigerating output reaches 15.31 kW in summer and the solar-enhanced natural ventilation air flow rate doubles in transitional seasons. The experimental investigation validated the practical effective operation of the adsorption cooling-based air-conditioning system. After 1-year operation, it is confirmed that the solar system contributes 70% total energy of the involved space for the weather conditions of Shanghai.

08/01278 Solar photovoltaic water pumping for remote locations

Meah, K. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 472–487.

Many parts of the world as well as the western US are rural in nature and consequently do not have electrical distribution lines in many parts of villages, farms, and ranches. Distribution line extension costs can run from US$10,000 to US$16,000/km, thereby making availability of electricity to small water pumping projects economically unattractive. But, ground water and sunlight are available, which make solar photovoltaic (SPV) powered water pumping more cost effective in these areas' small scale applications. Many western states including Wyoming are passing through the sixth year of drought with the consequent shortages of water for many applications. The Wyoming State Climatologist is predicting a possible 5–10 years of drought. Drought impacts the surface water right away, while it takes much longer to impact the underground aquifers. To mitigate the effect on the livestock and wildlife, Wyoming Governor Dave Freudenthal initiated a solar water pumping initiative in cooperation with the University of Wyoming, County Conservation Districts, Rural Electric Cooperatives, and ranching organizations. Solar water pumping has several advantages over traditional systems; for example, diesel or propane engines require not only expensive fuels, they also create noise and air pollution in many remote pristine areas. Solar systems are environment friendly, low maintenance, and have no fuel cost. In this paper the design, installation, site selection, and performance monitoring of the solar system for small-scale remote water pumping will be presented. This paper also presents technical, environmental, and economic benefits of the SPV water pumping system compared to stand alone generator and electric utility.

08/01279 The effect of south wall's outdoor absorption coefficient on time lag, decrement factor and temperature variations

Kontoleon, K. J. and Bikas, D. K. *Energy and Buildings*, 2007, 39, (9), 1011–1018.

In this study, the effect of outdoor absorption coefficient of an opaque wall on time lag, decrement factor and temperature variations is investigated by employing a dynamic thermal-network model. The model simulates heat transfer by conduction through the wall and considers convection boundary conditions under detailed forcing functions on the wall outer and inner surfaces. The transient analysis is based on the fundamental principles of thermal circuits and the well-known analogies between the thermal and electrical laws are employed. The effect of the solar absorptivity, is examined for representative wall formations including masonry, insulation and coatings on both surfaces. The insulation is placed as one or two layers on the outer, the inner or in the mid-centre of the masonry. The investigation is carried out for a wall with south orientation during the cooling season in the Mediterranean region. The analyses presume a non-sinusoidal periodical excitation that simulates precisely the effect of the outdoor environmental conditions. Computer results show how these varied aspects affect thermal inertia parameters and outdoor/indoor temperature peaks.

08/01280 Theoretical and experimental studies of an ethanol basin solar still

Namprakai, P. and Hirunlabh, J. *Energy*, 2007, 32, (12), 2376–2384.

A transient-state mathematical model for an ethanol basin solar still based on Spalding's work was developed. Driving force B was defined based on the mass balance between the evaporating and condensing surfaces. Mass transfer conductance (*g*) was obtained from an indoor experiment. Then productivity could be calculated. In order to validate the model an ethanol basin solar still was tested under outdoor conditions. The model had RMSEs of 4% and 23% of the measured mean temperature and productivity. The mean productivity was 0.33 kg/h when the mean solar radiation input was 1.95 MJ/m^2/h. The simulated distillate concentrations were 74, 59 and 24%v/v for ethanol solution concentrations of 50, 30 and 10%v/v. The monthly means of the simulated daily productivity and total daily solar radiation were linearly correlated. An indoor experimental equipment of the same type as that used for the outdoor experiments was constructed. Ethanol solutions with concentrations of 10–100%v/v were distilled. The ethanol solution temperature varied between 40 and 70 °C. The experimental data from the still was then used to find the *g* used for the above mathematical model. The still height had a slight effect on the productivity. Increasing the ethanol solution concentration by not more than around 80% v/v could improve the still productivity.

08/01281 Theory and experimental investigation of a weir-type inclined solar still

Sadineni, S. B. *et al. Energy*, 2008, 33, (1), 71–80.

A weir-type solar still is proposed to recover rejected water from the water purifying systems for solar hydrogen production. This consists of an inclined absorber plate formed to make weirs, as well as a top basin and a bottom basin. Water is flowed from the top basin over the weirs to the bottom collection basin. A small pump is used to return the unevaporated water to the top tank. Hourly distillate productivity of the still with double- and single-pane glass covers was measured and the latter showed higher production rates. The average distillate productivities for double- and single-pane glass covers are approximately 2.2 and 5.5 l/m^2/day in the months of August and September in Las Vegas, respectively. Mathematical models that can predict the hourly distillate productivity are developed. These compared well with the experimental results. Productivity of the weir-type still with a single-pane glass was also compared with conventional basin types tested at the same location. The productivity of the weir-type still is approximately 20% higher. The quality of distillate from the still is analysed to verify the ability of the still to meet the standards required by the electrolysers.

08/01282 Thermodynamic analysis of the CO_2-based Rankine cycle powered by solar energy

Zhang, X. R. *et al. International Journal of Energy Research*, 2007, 31, (14), 1414–1424.

Using carbon dioxide as working fluid receives increasing interest since the Kyoto Protocol. In this paper, thermodynamic analysis was conducted for proposed CO_2-based Rankine cycle powered by solar energy. It can be used to provide power output, refrigeration and hot water. Carbon dioxide is used as working fluid with supercritical state in solar collector. Theoretical analysis was carried out to investigate performances of the CO_2-based Rankine cycle. The interest was focused on comparison of the performance with that of solar cell and those when using other fluids as working fluids. In addition, the performance and characteristics of the thermodynamic cycle are studied for different seasons. The obtained results show that using CO_2 as working fluid in the Rankine cycle owns maximal thermal efficiency when the working temperature is lower than 250.0°C. The power generation efficiency is about 8%, which is comparable with that of solar cells. But in addition to power generation, the CO_2-based solar utilization system can also supply thermal energy.

Wind energy

08/01283 Acceptance of renewable energy innovation in Brazil – case study of wind energy

de Araújo, M. S. M. and de Freitas, M. A. V. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 584–591.

The paper presents some outputs of renewable energy power plants in Brazil, focusing in the case of wind energy. The information data are mainly acquired from a project developed by the authors with financial resources of Electric Energy National Agengy, United Nations Development Program and Ministry of Science and Technology. It was used as the socio environmental impacts to evaluate the acceptance aspect, using as examples some case studies implemented in Brazil and the previous experience of the authors.

08/01284 Assessing offshore wind resources: an accessible methodology

Dhanju, A. *et al. Renewable Energy*, 2008, 33, (1), 55–64.

This paper describes a method for assessing the electric production and value of wind resources, specifically for the offshore environment. Three steps constitute the method. First, the available area is mapped, delimiting bathymetric areas based on turbine tower technology, then assess competing uses of the ocean to establish exclusion zones. From exclusion zones, bathymetry, and turbine tower water depth limitations, the water sheet area available for wind turbines is calculated. The second step is calculation of power production starting from available area, which determines the location and count of turbines. Then existing wind data are extrapolated to turbine height and, along with the turbine power output curve, they are used to establish the expected electric power production on an hourly basis. The third step calculates market value based on the hourly electric market at the nearest electric grid node. To illustrate these methods, the offshore wind resource of the US state of Delaware is assessed. The authors find year-round average output of over 5200 MW, or about four times the average electrical consumption of the state. On local wholesale electricity markets, this would produce just over $2 billion/year in revenue. Because the methods described here do not rely on constructing meteorological towers nor on proprietary software, they are more accessible to a local government, state college, or other organization. For example, these methods can be carried out as an initial assessment of resources, or by a government or public entity as a check on claims by private applicants.

08/01285 Attitudes towards on-land and offshore wind power development in Denmark; choice of development strategy

Ladenburg, J. *Renewable Energy*, 2008, 33, (1), 111–118.

Wind power generation is expected to increase significantly in the near future. Owing to the increasingly limited possibilities for using on-land turbines, offshore wind generation is a potential alternative. However, wind turbines located offshore are still associated with visual disamenities potentially making offshore location a less attractive alternative to on-land wind power generation. The present paper analyses attitudes towards both on-land and offshore wind power development using a probit model. It also discusses the elicited determinants of attitude in relation to developing wind power on-land or offshore. Compared to other papers on attitude, the paper is unique in the sense that the Danish population has considerable experience with the different impacts associated with wind turbines compared to most of the other countries investing in wind power generation. This is particularly evident with regards to offshore development. The paper establishes that whilst offshore wind farms are preferred to on-land development, the results also imply that on-land development is still a feasible alternative. In that relation, differences in wind power generation costs and the substitution of smaller on-land turbines with fewer but larger turbines might make on-land development even more attractive. On a more detailed level, younger respondents are more positive towards wind power than older respondents. Interestingly, respondents living close to either on-land or offshore wind turbines did not display a more negative attitude towards wind power generation when compared to respondents who were not living close to wind turbines.

08/01286 Characteristics of wind power on Savonius rotor using a guide-box tunnel

Irabu, K. and Roy, J. N. *Experimental Thermal and Fluid Science*, 2007, 32, (2), 580–586.

This study investigates to improve and adjust the output power of Savonius rotor under various wind power and suggests the method of prevention the rotor from strong wind disaster. A guide-box tunnel (like a rectangular box) is used as a wind passage in which a test rotor is included. The area ratio between the inlet and exit of it is variable to adjust the inlet mass flow rate or input power. At first, the experiment was conducted to find the adequate configuration that would provide the best relative performance. The present experiment, however, does not include the test to retain the guide-box tunnel from the strong wind. The experiments include the static torque test of the fixed rotor at any phase angle and the dynamic torque test at rotation of them. Consequently, it was found that the maximum rotor rotational speed was achieved in the range of the guide-box area ratio between 0.3 and 0.7 and the value of the output power coefficient of the rotor with guide-box tunnel of the area ratio 0.43 increases about 1.5 times with three blades and 1.23 times with two blades greater than that without guide-box tunnel, respectively. It seemed that the performance of Savonius rotor within the guide-box tunnel is comparable enough with other methods for augmentation and control of the output.

08/01287 Developments in the utilisation of wind energy in Greece

Papadopoulos, A. M. *et al. Renewable Energy*, 2008, 33, (1), 105–110.

The utilization of renewable energy sources, and wind energy in particular, can be described in Greece as a story of high expectations, intense initial entrepreneurial interest, delays in the start-up phase of projects and, some times, disappointments during the implementation procedure. Still, the current situation gives reasons for some optimism. This paper provides a review of the present technological background in wind generators, as found in the Greek market, as well as a detailed analysis of the legislative framework. Moreover, it aims to analyse the development of the process of granting investment and production permissions and their implementation since 1999. Thus, it is possible to identify the main reasons for the problems that occurred since the liberalization of the electricity market and to account for the interest in wind energy. Finally, comments and proposals are formulated concerning the hidden barriers, the pertinent problems and the promising perspectives of the use of wind energy in Greece.

08/01288 Energy capture by a small wind-energy conversion system

Arifujjaman, M. *et al. Applied Energy*, 2008, 85, (1), 41–51.

Furling is the most common method used by the small wind-turbine industry to control the aerodynamic power extraction from the wind. A small wind-turbine with furling mechanism and its resulting dynamics are modelled using Matlab/Simulink platform in this paper. The model simulates regulating the speed of the wind-turbine via a load-control method. Tip-speed ratio and hill-climbing control methods for maximum-power extraction from a small wind-turbine are investigated. Two dynamic controllers are designed and their behaviours simulated. In the first method, the controller uses the wind-speed and rotor speed information to control the load in order to operate the wind-turbine at its optimal tip-speed ratio. In the second method, the controller compares the output power of the turbine with the previous power, and controls the load based on the power difference. In order to determine a suitable control strategy for the small wind-energy conversion system, several tests are performed. Wind-speed versus power-curve and annual energy capture of the system for each control method are determined for wind conditions in St. John's, Newfoundland. The annual energy-capture is determined using the bin's power-curve method. Wind-speed data and Rayleigh distribution of St. John's, Newfoundland are used to determine the annual energy-capture. The results of the simulations indicate that the energy capture of a wind-turbine depends not only on the control strategy but on the wind-speed and Rayleigh distribution. The results of the investigation lead to the conclusion that the hill-climbing method of control results in a greater annual energy-output.

08/01289 Energy performances and life cycle assessment of an Italian wind farm

Ardente, F. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (1), 200–217.

Renewable energy sources are often presented as 'clean'. A more correct definition is that they are 'cleaner' than ones based on fossil fuel conversion. When the energy consumption and the environmental impacts related to the plant's life-cycle are considered, a more comprehensive assessment of these technologies can be carried out. This paper aims to evaluate the energy and the environmental performances of the electricity production of a wind farm. The impacts related to all the phases of the wind farm construction and operation have been compared to the environmental benefits due to the 'green' electricity generation during its useful life. In other terms, the goal is to trace the ecoprofile of the production of 1 kWh of electricity. A life cycle assessment has been performed based on data related to an Italian wind farm: production and deliver of energy and raw materials, components manufacturing, transports, installation, maintenance, disassembly and disposal have been analysed. The attention focused to those life cycle steps generally neglected or not adequately investigated as installation, civil works and maintenance. The results can be assumed as representative of the Italian context and they can represent a further incentive to the diffusion of wind farms. In fact, the environmental performances of the wind farm have been compared to other power energy generation systems. The results showed a great environmental convenience of the inquired technology.

08/01290 Practical ways of evaluating wind speed persistence

Koçak, K. *Energy*, 2008, 33, (1), 65–70.

Wind speed persistence is a measure of the mean wind speed duration over a given period of time at any location. This definition implies that wind speed persistence means a positive serial correlation in time series. The wind speed persistence provides useful information about the general climatological characteristics of the wind persisting at a given location. Therefore, wind speed persistence should be taken into account in many studies such as weather forecast, site selection for wind turbines and synthetic generation of the wind speed data. On the other hand, if wind direction information is considered together with the wind speed then this type of persistence can be used for additional purposes such as forest fires, dispersion of the air pollutants, building ventilation, etc. In this study, three different methods with some modifications of the previous methods have been applied to the wind speed data obtained from the meteorology stations located at the northwest part of Turkey. These methods are based on autocorrelation function, conditional probability and the wind speed duration curves. It has been shown that the proposed methods clearly reflect the persistence properties of the wind speed in the study area.

08/01291 Profitability of wind energy: short-term risk factors and possible improvements

Montes, G. M. and Martín, E. P. *Renewable and Sustainable Energy Reviews*, 2007, 11, (9), 2191–2200.

The wind energy industry has grown considerably in recent years. If the current rate of growth of installed capacity of 1500 MW per year continues, by 2006 Spain will achieve the objective established for 2010 in the 'Plan to Promote Renewable Energies' or for 2008 in the more ambitious 'Plan for Electrical and Gas Installations'. Achieving these important goals, which require significant investment, depends upon the continued stability of salaries and the willingness of banks to provide financing. Therefore, those factors that had the greatest short-term impact on the economic viability of wind energy projects in Spain are studied and it was found that the inherent risk within the sector can become a real obstacle in terms of development and short-term financing. Given the possibility of carrying out financial analysis that is more exhaustive than traditionally employed methods, the various models for evaluating investment in risk conditions were studied with the aim of choosing the ideal tool that takes account of the highly fortuitous nature of wind velocity.

08/01292 Short term wind speed forecasting for wind turbine applications using linear prediction method

Riahy, G. H. and Abedi, M. *Renewable Energy*, 2008, 33, (1), 35–41.

In this paper a new method, based on linear prediction, is proposed for wind speed forecasting. The method utilizes the 'linear prediction' method in conjunction with 'filtering' of the wind speed waveform. The filtering eliminates the undesired parts of the frequency spectrum (i.e. smoothing) of the measured wind speed which is less effective in an application, for example, in a wind energy conversion system. The linear prediction method is intuitively explained with some easy to follow case studies to clarify the complex underlying mathematics. For verification purposes, the proposed method is compared with real wind speed data based on experimental results. The results show the effectiveness of the linear prediction method.

08/01293 Wind energy development in Pakistan

Mirza, U. K. *et al. Renewable and Sustainable Energy Reviews*, 2007, 11, (9), 2179–2190.

Pakistan has a very limited fossil fuel resource base. The poor economy does not allow the import of fossil fuels, particularly oil, on a large scale. Moreover, too much reliance on imported oil is critical from energy security point of view. A large fraction of the population lives in remote areas and is still waiting to be connected to the national electricity grid. To help these remote communities in particular, and to overcome energy shortages in general, Pakistan needs to develop its indigenous energy resources like hydropower, solar and wind. More than 1000 km long coastline in south and some places in northern mountainous areas provide an excellent resource of wind energy. This vast potential can be exploited to produce electricity on both community and wind farm scales. Applications other than electricity production, such as water pumping, also have vast applications. This article discusses the past, the present and the future of wind energy use in Pakistan. The efforts for the utilization of wind energy in the country are presented as well, along with barriers to its development. It is concluded that the potential exists, but significant efforts are needed to effectively make use of this cheap renewable energy source.

08/01294 Wind power usage and prediction prospects in Lithuania

Marciukaitis, M. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (1), 265–277.

Wind power is not widely used in Lithuania yet. Currently only few small-scale wind turbines with total capacity of 0.995 MW are operating. However, Lithuania is planning to install wind power plants with total capacity of 200 MW by the year 2010. In this paper, wind energy resource assessment experience as well as current situation and future prospective of wind energy usage in Lithuania are reviewed. Main features of Lithuanian electrical system are presented and issues related to wind energy integration in electrical networks are discussed. The aim of this work is to point up the importance of wind power prediction in Lithuania. Thus a short review of wind power prediction methods is presented which has shown that selection of most suitable prediction models for Lithuanian conditions requires detailed research.

Others, including economics

08/01295 Biomass for heat or as transportation fuel? A comparison between two model-based studies

Grahn, M. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 747–758.

In two different energy economy models of the global energy system, the cost-effective use of biomass under a stringent carbon constraint has been analysed. The first concluded that it is cost-effective to use biofuels for transportation, whereas the second found that it is more cost-effective to use most of the biomass to generate heat and process heat, despite the fact that assumptions about the cost of biofuels production is similar in the models. In this study, the two models are compared with the purpose of finding an explanation for these different results. It was found that both models suggest that biomass is most cost-effectively used for heat production for low carbon taxes (below US\$50–100/tC, depending on the year in question). But for higher carbon taxes, the cost-effective choice reverses in the BEAP model, but not in the GET model. The reason for this is that GET includes hydrogen from carbon-free energy sources as a technology option, whereas that option is not allowed in the BEAP model. In all other sectors, both models include carbon-free options above biomass. Thus, with higher carbon taxes, biomass will eventually become the cost-effective choice in the transportation sector in BEAP, regardless of its technology cost parameters.

08/01296 Consumer willingness-to-pay for biopower: results from focus groups

Hite, D. *et al. Biomass and Bioenergy*, 2008, 32, (1), 11–17.

To find out whether consumers are willing to pay a surcharge for biopower, the Alabama Department of Agriculture and Industries hosted consumer focus groups at four locations in Alabama. Results showed that consumers were willing to pay a premium in line with the costs, but that most did not have much prior information about green energy options.

08/01297 Critical evaluation of the hydropower applications in Greece

Kaldellis, J. K. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 218–234.

Hydropower is a proven technology for electricity generation, contributing with almost 20% to the fulfilment of the planet electricity demand. Hydropower is also renewable because it draws its essential energy from the sun and particularly from the hydrological cycle. Greece and more precisely the west and north part of the mainland possesses significant hydropower potential that is up to now partially exploited. In the present survey, one investigates the existing situation concerning the applications of hydropower plants in Greece, while the results obtained are compared with the corresponding international and European situation. Subsequently, emphasis is laid on estimating the electricity-generation utilization degree of the existing large hydropower stations, using 25-year long official data. The results obtained underline the fact that the electricity generation is not a priority for the national water management policy and most Greek hydropower stations are used mainly to meet the corresponding peak load demand. On the other hand, increased interest to create numerous new small hydropower plants throughout Greece has been expressed during the last 5 years. According to the information gathered and analysed, one may state that the available local hydropower potential is quite promising and can substantially contribute to the accomplishment of the national-EU target to cover the 21% of the corresponding electricity consumption from renewable resources. For this purpose one should first define an approved and rational water resources management plan and secondly support the increased utilization of large and small hydropower plants for electricity generation. In this case, properly designed hydropower plants should lead to considerable profits, contributing also in the country's independency from imported oil and accomplishing the Kyoto protocol obligations.

08/01298 Developing a sustainability framework for the assessment of bioenergy systems

Elghali, L. *et al. Energy Policy*, 2007, 35, (12), 6075–6083.

The potential for biomass to contribute to energy supply in a low-carbon economy is well recognized. However, for the sector to contribute fully to sustainable development in the UK, specific exploitation routes must meet the three sets of criteria usually recognized as representing the tests for sustainability: economic viability in the market and fiscal framework within which the supply chain operates; environmental performance, including, but not limited to, low carbon dioxide emissions over the complete fuel cycle; and social acceptability, with the benefits of using biomass recognized as outweighing any negative social impacts. This paper describes an approach to developing a methodology to establish a sustainability framework for the assessment of bioenergy systems to provide practical advice for policy makers, planners and the bioenergy industry, and thus to support policy development and bioenergy deployment at different scales. The approach uses multi-criteria decision analysis and decision-conferencing, to explore how such a process is able to integrate and reconcile the interests and concerns of diverse stakeholder groups.

08/01299 Development of thermoelectric oxides for renewable energy conversion technologies

Weidenkaff, A. *et al. Renewable energy*, 2008, 33, (2), 342–347.

Geothermal and solar heat can be directly converted into electricity by using thermoelectric generators. Perovskite-type metal oxides are potential materials to improve the efficiency of these devices. Cobaltates with *p*-type conductivity and *n*-type manganates are considered for the development of a ceramic thermoelectric converter. Sintered pellets and thin PLD films with the composition $La_{1-x}Ca_xMO_{3-\delta}$ ($x = 0$, 0.3, 0.4) ($M = Co$, Mn) were synthesized and characterized concerning their thermoelectric properties in a broad temperature range. It was found that similar to polycrystalline samples the electrical conductivity of $LaCoO_3$ increases significantly with 40% Ca-substitution due to the formation of Co^{4+} ions while the thermopower decreases. The thermopower values of the $La_{0.8}Ca_{0.2}MnO_{3-\delta}$ films have a negative sign, but become large and positive at temperatures of 1000 K.

08/01300 Effects of utilizing seawater as a cooling source system in a commercial complex

Song, Y.-H *et al. Energy and Buildings*, 2007, 39, (10), 1080–1087.

This paper treats energy and cost performance of a cooling source system with indirect seawater utilization for air conditioning in a commercial complex. Seawater utilization has merits as a cooling source, because seawater temperature is lower than outdoor air in summer and it is cost effective because there is no water monetary cost. Actual operating data has been measured for about 2 years and the chiller and system co-efficient of performance (COP) have indicated about 4.77 and 2.93, respectively, even in summer season and the mean efficiency of the thermal storage system was about 89.9% taking into account heat loss of pumps. In addition, the authors have constructed simulation models for cooling tower systems, air cooling chiller systems and direct seawater utilization systems then compared them to this system. The electric power consumption of the indirect seawater utilization system was almost the same as the other systems except the air cooling chiller system, because using lower seawater temperature made the chiller efficiency higher. In conclusion, the results showed the indirect seawater utilization system was able to improve the system COP compared to air cooling chiller system, and cancel water consumption compared with the cooling tower system, and cut down an initial and maintenance costs compared with the direct seawater utilization system.

08/01301 Efficiency analysis of hydroelectric generating plants: a case study for Portugal

Barros, C. P. *Energy Economics*, 2008, 30, (1), 59–75.

This paper estimates changes in total productivity, breaking this down into technically efficient change and technological change, by means of data envelopment analysis (DEA) applied to the hydroelectric energy generating plants of EDP – the Portugal Electricity Company. The aim of this procedure is to seek out those best practices that will lead to improved performance in the energy market. The plants are ranked according to their change in total productivity for the period 2001–2004, concluding that some plants experienced productivity growth while others experienced a decrease in productivity. The implications arising from the study are that EDP should adopt an internal benchmark management procedure in order to evaluate the relative position of each hydroelectric generating plant and to adopt managerial strategies designed to catch up with the frontier of 'best practices'. As the frontier is shifting along the time, constant efforts are needed in this respect along the time.

08/01302 How to transform local energy systems towards bioenergy? Three strategy models for transformation

Mårtensson, K. and Westerberg, K. *Energy Policy*, 2007, 35, (12), 6095–6105.

During the last decades, the actors within the energy sector in Sweden – as well as in many other countries – have faced increasing demands to transform the energy system towards ecological sustainability. In Sweden these demands have led to numerous policies and economic incentives promoting the use of renewables (which in the Swedish discourse often also includes a connotation of 'indigenous energy sources'), and especially the promotion of bioenergy. To be successful, however, these policies and economic incentives need to be interpreted and adapted to different local contexts and translated into actual transformation processes. In Sweden the municipal authorities have played an important role as interpreters of such institutional frameworks and implementers of local transformation processes. In this article, the authors re-construct three transformation processes implemented by local municipal authorities, chiselling out the different strategy models developed through them. It is argued that such re-constructions help to make visible the different and complex interactions between national institutional frameworks and local contexts as well as interactions within such local contexts. It is hoped that the strategy models presented can contribute to the understanding of the different kinds of local actions that can foster a further implementation of bioenergy into the energy system.

08/01303 Modeling of hybrid renewable energy systems

Deshmukh, M. K. and Deshmukh, S. S. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 235–249.

Hybrid renewable energy systems (HRES) are becoming popular for remote area power generation applications due to advances in renewable energy technologies and subsequent rise in prices of petroleum products. Economic aspects of these technologies are sufficiently promising to include them in developing power generation capacity for developing countries. Research and development efforts in solar, wind, and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources. The paper describes methodologies to model HRES components, HRES designs and their evaluation. The trends in HRES design show that the hybrid PV/wind energy systems are becoming gaining popular. The issues related to penetration of these energy systems in the present distribution network are highlighted.

08/01304 Possible effects of the hurricane Gudrun on the regional Swedish forest energy supply

Björheden, R. *Biomass and Bioenergy*, 2007, 31, (9), 617–622.

This paper presents a snapshot speculative analysis of some possible effects of the massive windthrow in south Sweden on 8–9 January 2005. Hurricane Gudrun damaged buildings and blocked roads, making large areas inaccessible except by helicopter. Electricity and telecommunications were shambolic. Around 70 million cubic metres were windthrown, equalling a 'normal' Swedish annual felling – a gross value exceeding €20 billion. The paper presents the subsequent restoration work that has placed a special focus on the forest sector. In south Sweden, logging work will last for a couple of years. The roundwood market will be severely strained. For individual forest owners, the economic effects of the storm are often disastrous. To ensure that forest owners will retrieve at least part of the pre-storm forest value, restoration aims at the salvaging of maximum value. Sawmills try to store the most valuable timber for years to come, decreasing the risk of painful capacity adjustments and protecting export opportunities. Forest fuel value is low compared to sawlogs and pulpwood. Thus, the forest energy sector has received little attention. Forest chippers normally contribute important marginal quantities of wood fuels, but since no logging residues will be harvested from the windthrown forests for a period of 2–3 years, they are put out of business and may disappear from the market. Heating and power plants will receive an abundance of industrial by-products in the coming 2–3 years, followed by a period of expected shortage of woody biomass for energy production. With few forest chippers left, the situation will be troublesome.

08/01305 Primary and secondary frequency regulation in a longitudinal hydrothermal system by Liapunov method

Moya, O. and Ramos, A. *Electric Power Systems Research*, 2008, 78, (1), 137–146.

The problem of primary and secondary frequency regulation of a multimachine power system is analysed with a Liapunov function method based on a quadratic performance index. The main purpose is to determine the best set of parameters of primary and secondary regulation according to an optimization criterion. The objective consists of achieving a settling time as short as possible which is relevant in a longitudinal system, whose structure includes long transmission lines with a reduced number of loops. Frequency and turbine valve positions are used as state variables, and optimal control parameters for primary and secondary regulation are used as control variables. Performance index behaviour under different frequency control schemes is then used to determine the optimal values to set the droops and gains of primary and secondary regulation. Tests for different disturbance locations and selection of regulating units are simulated on a model of the Chilean Central Interconnected System (CIS). It is shown that significant improvements can be achieved with the proposed method.

08/01306 Regulation and optimization of the biogas process: propionate as a key parameter

Nielsen, H. B. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 820–830.

The use of volatile fatty acids (VFA) as process indicators in biogas reactors treating manure together with industrial waste was studied. At a full-scale biogas plant, an online VFA sensor was installed in order to study VFA dynamics during stable and unstable operation. During stable operation acetate increased significantly during the feeding periods from a level of 2–4 to 12–17 mM, but the concentration generally dropped to about the same level as before feeding. The fluctuations in the propionate were more moderate than for acetate but the average level rose during 1 week of operation from 0.6 to 2.9 mM. A process disturbance caused by overloading with industrial waste was reflected by a significant increase in all VFA concentrations. During the recovery of the process, the return of propionate back to the steady-state level was 2–3 days slower than any other VFA and propionate could best describe the normalizing of the process. In a lab-scale continuously stirred tank reactor experiment, with manure as main substrate, the prospective of using either propionate concentration or methane production as single process indicators was studied. Propionate was found to be the best indicator. Thus, a process breakdown caused by organic overloading with meat and bone meal and lipids was indicated by changes in propionate concentration 12–18 days before a decrease in methane production was observed. Furthermore, a more efficient and stable utilization of the substrate was observed when propionate was used as process indicator.

08/01307 Renewable energy technologies in the Maldives – realizing the potential

van Alphen, K. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (1), 162–180.

Like in many small island developing states, the techno-economic potential of renewable energy technologies (RETs) in the Maldives is substantial. However, it is not certain that these economically viable RETs will indeed be implemented and utilized, since this is greatly influenced by various social, institutional and political factors (i.e. the innovation system). In order to steer away from activities that enhance the current fossil fuel based lock-in situation and create an environment that increases the chance of a successful transfer and diffusion of RETs, several projects have been set up in the Maldives. These projects have been initiated by the Global Environmental Facility, the United Nations Development Program, and the European Commission. In this article, these projects are evaluated by analysing whether or not they strengthen the local renewable energy innovation system. This evaluation shows that these RE programs strengthen most of the key processes necessary in an innovation system conducive to technology transfer. However, as not enough attention is being paid to local entrepreneurial activities and the creation of a domestic market for RETs, the process of RET transfer might run the risk of stagnation after completion of the RE programs.

08/01308 Renewislands – renewable energy solutions for islands

Chen, F. *et al. Renewable and Sustainable Energy Reviews*, 2007, 11, (8), 1888–1902.

Increase of the global energy demand and environmental problems relating to fossil energy utilization request the new energy sources to replace the traditional fossil fuels. With respect to energy production, most of the islands in European Union and in the other parts of the world, depend on importation, mainly from oil and its related products. The global development of renewable energy technologies can assure sustainable supply of power for islands. To overcome the limitation of the sources of renewable energy, hydrogen is utilized as a storage medium integrated with intermittent renewable energy sources such as wind and solar. This paper introduces the programme of 'Renewislands – renewable energy solutions for islands', the work tasks, details of the design of the activities to develop solutions integrating intermittent renewable energy supply (RES), fuel cell and hydrogen infrastructure to promote RES and innovative decentralized power systems penetration in islands; main results achieved in each work packages are presented; in addition, the development of intermittent renewable energy penetration in specific European Islands are reviewed briefly.

08/01309 Review of green electricity production in Slovenia

Stritih, U. *et al. Renewable and Sustainable Energy Reviews*, 2007, 11, (9), 2201–2208.

The article presents a short review of electricity production from renewable energy sources in Slovenia. In Introduction the term of 'green electricity' is defined. Comparison of structures of electricity production is presented for the years 1990 and 2003. The main part of the article presents an approximate data for technical and theoretical potentials of renewable energy sources in Slovenia. State-of-the-art regarding individual technologies of electricity production from renewable energy sources and political targets according to Directive 2001/77/EC for green electricity are also presented. At the end of the article different stimulation models are described and uniform prices and premiums for the purchase of green electrical energy are presented.

08/01310 Role of BCHP in energy and environmental sustainable development and its prospects in China

Hao, X. *et al. Renewable and Sustainable Energy Reviews*, 2007, 11, (8), 1827–1842.

During the last century, worldwide environment degradation has been more and more serious, and achieving environmental sustainable development is desirable. As many environmental issues are directly or indirectly energy related, energy sustainable development is one of the most important prerequisites for environmental sustainable development. Renewable energy technologies and energy conservation are two solutions for energy sustainable development. At present, energy-saving technology is a feasible and an effective way to achieve energy and environmental sustainable development, although renewable energy may be final solution to environmental issues. Building cooling, heating, and power (BCHP) technology, which usually use natural gas as primary energy, has high efficiency of energy utilization due to the utilization of distributed power generation and heat recovery, and thus is a promising energy conservation technology. BCHP can reduce pollutants emission and thus protects the environment besides improving IAQ and increasing reliability of building energy supply. As the largest developing country, China is just in the process of adjusting energy structure and improving energy efficiency. Because of its significant role in energy and environmental sustainable development, developing BCHP in China will help the country in optimizing energy proportion, increasing energy efficiency, and protecting environment. Therefore, BCHP technology will have broad prospects in China and it will promote the country's energy and environmental sustainable development.

14 FUEL SCIENCE AND TECHNOLOGY

Fundamental science, analysis, instrumentation

08/01311 3D numerical simulations of hypervapotron cooling concept

Pascal-Ribot, S. *et al. Fusion Engineering and Design*, 2007, 82, (15–24), 1781–1785.

A hypervapotron cooling concept armoured with flat tiles is considered as a possible technique to handle heat fluxes about 20 MW/m^2 produced in a fusion reactor. As far as the optimization of the hypervapotron concept is concerned, this paper provides promising predictive 3D numerical simulations. These simulations model both the two-phase flow and the solid heat conduction within the hypervapotron structure with the coupled computer codes Neptune CFD and Syrthes.

08/01312 A compensation scheme for CVT transient effects using artificial neural network

Zadeh, H. K. and Li, Z. *Electric Power Systems Research*, 2008, 78, (1), 30–38.

Capacitive voltage transformers (CVTs) provide instrument-level voltage signals to meters and protective relays in high voltage (HV) systems. The transients in CVTs could lead to protective relay maloperation. This paper proposes the use of an artificial neural network (ANN) scheme to correct CVT secondary waveform distortions due to CVT transient. This is accomplished by using samples of voltage signals to achieve a good approximation of the inverse transfer function of CVTs, thus an accurate estimation of the primary voltages. Simulations are performed and the impacts of different parameters are studied. Performance results show that the proposed scheme is accurate and reliable. The proposed scheme can also be implemented on a digital signal processor board for real-time application.

08/01313 A neural network evaluation model for individual thermal comfort

Liu, W. *et al. Energy and Buildings*, 2007, 39, (10), 1115–1122.

An evaluation model for individual thermal comfort is presented based on the BP neural network. The train data came from a thermal comfort survey. The evaluation results of the model showed a good match with the subject's real thermal sensation, which indicated that the model can be used to evaluate individual thermal comfort rightly. Taken a room air conditioner as an example, the application of the NNEM in creating a microenvironment for individual was discussed. The result showed that the NNEM can play an important role of connecting individual thermal comfort with the control on the air conditioner.

08/01314 A new stable finite volume method for predicting thermal performance of a whole building

Luo, C. *et al. Building and Environment*, 2008, 43, (1), 37–43.

Discretized governing equations involving only temperatures and heat fluxes at both surfaces of a solid wall layer were obtained by combining a new stable finite volume scheme for the two inner nodes of the wall layer with the surface diffusion equations (discretized by third order equations). The finite volume scheme for the inner nodes of the layer is proved to be stable with its truncation error being $O(\Delta x^4, \Delta x^2 \Delta t^2)$. A special analytical solution for a solid wall was used to evaluate different schemes for the inner nodes, showing that the new proposed scheme performs better than all other schemes for time steps of 3600 and 600 s. Finally, this scheme was used to simulate a whole house and the predicted zonal air temperature, and surface temperatures agreed well with measured values.

08/01315 A spatially adaptive grid-refinement approach for the finite element solution of the even-parity Boltzmann transport equation

Mirza, A. M. *et al. Annals of Nuclear Energy*, 2007, 34, (7), 600–613.

A spatially adaptive grid-refinement approach has been investigated to solve the even-parity Boltzmann transport equation. A residual based *a posteriori* error estimation scheme has been utilized for checking the approximate solutions for various finite element grids. The local particle balance has been considered as an error assessment criterion. To implement the adaptive approach, a computer program ADAFENT (adaptive finite elements for neutron transport) has been developed to solve the second order even-parity Boltzmann transport equation using K^+ variational principle for slab geometry. The program has a core K^+ module which employs Lagrange polynomials as spatial basis functions for the finite element formulation and Legendre polynomials for the directional dependence of the solution. The core module is called in by the adaptive grid generator to determine local gradients and residuals to explore the possibility of grid refinements in appropriate regions of the problem. The a posteriori error estimation scheme has been implemented in the outer grid refining iteration module. Numerical experiments indicate that local errors are large in regions where the flux gradients are large. A comparison of the spatially adaptive grid-refinement approach with that of uniform meshing approach for various benchmark cases confirms its superiority in greatly enhancing the accuracy of the solution without increasing the number of unknown coefficients. A reduction in the local errors of the order of 10^2 has been achieved using the new approach in some cases.

08/01316 A statistical methodology for quantification of uncertainty in best estimate code physical models

Vinai, P. *et al. Annals of Nuclear Energy*, 2007, 34, (8), 628–640.

A novel uncertainty assessment methodology, based on a statistical non-parametric approach, is presented in this paper. It achieves quantification of code physical model uncertainty by making use of model performance information obtained from studies of appropriate separate-effect tests. Uncertainties are quantified in the form of estimated probability density functions, calculated with a newly developed non-parametric estimator. The new estimator objectively predicts the probability distribution of the model's 'error' (its uncertainty) from databases reflecting the model's accuracy on the basis of available experiments. The methodology is completed by applying a novel multi-dimensional clustering technique based on the comparison of model error samples with the Kruskall–Wallis test. This takes into account the fact that a model's uncertainty depends on system conditions, since a best estimate code can give predictions for which the accuracy is affected by the regions of the physical space in which the experiments occur. The final result is an objective, rigorous and accurate manner of assigning uncertainty to coded models, i.e. the input information needed by code uncertainty propagation methodologies used for assessing the accuracy of best estimate codes in nuclear systems analysis. The new methodology has been applied to the quantification of the uncertainty in the RETRAN-3D void model and then used in the analysis of an independent separate-effect experiment. This has clearly demonstrated the basic feasibility of the approach, as well as its advantages in yielding narrower uncertainty bands in quantifying the code's accuracy for void fraction predictions.

08/01317 Allocation decisions in network industries

Bolle, F. *Energy Economics*, 2008, 30, (1), 97–112.

In this paper, the author wants to propagate a new analytical tool: the usage of menu auctions for modelling complicated auctions, negotiations, rent seeking, etc. is advocated, because, contrary to 'normal' auctions and bargaining models, an arbitrary number of additional aspects can be taken into account. After concentrating on 'truthful equilibria' a certain broad class of menu auctions show unique and efficient allocations. Under an additional concavity condition even the equilibrium bids are unique. Two examples are discussed: the privatization of a state-owned industry and the buying of wholesale electricity (concluding contracts with a number of producers) by a utility. These examples also serve to trace the sources of 'non-concavities' which can prevent the uniqueness of bids and can provide the auctioneer with incentives to exclude bidders from the competition.

08/01318 An exergy analysis on the performance of a counterflow wet cooling tower

Muangnoi, T. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 910–917.

Cooling towers are used to extract waste heat from water to atmospheric air. An energy analysis is usually used to investigate the performance characteristics of cooling tower. However, the energy concept alone is insufficient to describe some important viewpoints on energy utilization. In this study, an exergy analysis is used to indicate exergy and exergy destruction of water and air flowing through the cooling tower. Mathematical model based on heat and mass transfer principle is developed to find the properties of water and air, which will be further used in exergy analysis. The model is validated against experimental data. It is noted from the results that the amount of exergy supplied by water is larger than that absorbed by air, because the system produces entropy. To depict the utilizable exergy between water and air, exergy of each working fluid along the tower are presented. The results show that water exergy decreases continuously from top to bottom. On the other hand, air exergy is expressed in terms of convective and evaporative heat transfer. Exergy of air via convective heat transfer initially loses at inlet and slightly recovers along the flow before leaving the tower. However, exergy of air via evaporative heat transfer is generally high and able to consume exergy supplied by water. Exergy destruction is defined as the difference between water exergy change and air exergy change. It reveals that the cooling processes due to thermodynamics irreversibility perform poorly at bottom and gradually improve along the height of the tower. The results show that the lowest exergy destruction is located at the top of the tower.

08/01319 Analytical minimization of overall conductance and heat transfer area in refrigeration and heat pump systems and its numerical confirmation

Sarkar, J. *et al. Energy Conversion and Management*, 2007, 48, (4), 1245–1250.

Minimization of heat exchanger area for a specified capacity is very important in the design of refrigeration and heat pump systems, yielding space, weight and cost benefits. In this study, minimization of overall conductance and total area per unit capacity of refrigeration and heat pump systems has been performed analytically. The analysis is performed for constant temperature heat sources and sinks considering both internal and external irreversibilities. Expressions are obtained for optimum hot and cold side refrigerant temperatures, conductance and heat exchanger area ratios. The analytical results have been confirmed by those obtained from a detailed numerical simulation of actual ammonia based refrigeration and heat pump systems, and good agreement is observed. Such theoretical models can be employed as simple yet effective design guidelines for real systems as demonstrated here.

08/01320 Anti-predatory particle swarm optimization: solution to nonconvex economic dispatch problems

Selvakumar, A. I. and Thanushkodi, K. *Electric Power Systems Research*, 2008, 78, (1), 2–10.

This paper proposes a new particle swarm optimization (PSO) strategy namely, anti-predatory particle swarm optimization (APSO) to solve nonconvex economic dispatch problems. In the classical PSO, the movement of a particle (bird) is governed by three behaviours: inertial, cognitive and social. The cognitive and social behaviours are the components of the foraging activity, which help the swarm of birds to locate food. Another activity that is observed in birds is the anti-predatory nature, which helps the swarm to escape from the predators. In this work, the anti-predatory activity is modelled and embedded in the classical PSO to form APSO. This inclusion enhances the exploration capability of the swarm. To validate the proposed APSO model, it is applied to two test systems having nonconvex solution spaces. Satisfactory results are obtained when compared with previous approaches.

08/01321 Assessment of homotopy analysis method and homotopy perturbation method in non-linear heat transfer equation

Domairry, G. and Nadim, N. *International Communications in Heat and Mass Transfer*, 2008, 35, (1), 93–102.

Two new analytical methods to solve non-linear heat transfer equations are homotopy perturbation method and homotopy analysis method. Here, homotopy analysis method, which gives a vast freedom to choose the answer type, is applied to solve nonlinear heat transfer differential equations and analytical results are compared with those of HPM and the numerical results. In this study, the procedure of HAM is applied to two cases in different ways according to the physics of the target problem. Comparing the two methods, attention is focused on the results accuracy; and applicability of different methods in many cases with different limitation is studied. In the two examples of this paper, the effect of small parameter increaser on the accuracy of the analytical results of two methods also has been studied. The first differential equation is the modelling equation of a cooling lumped system with combined convection and radiation. The second one is the modelling equation of heat transfer with conduction in a slab of thermal dependent conductivity.

08/01322 Boiling heat transfer of R-22, R-134a, and CO_2 in horizontal smooth minichannels

Choi, K.-I. *et al. International Journal of Refrigeration*, 2007, 30, (8), 1336–1346.

This study examined convective boiling heat transfer in horizontal minichannels using R-22, R-134a, and CO_2. The local heat transfer coefficients were obtained for heat fluxes ranging from 10 to 40 $\mathrm{kW\,m^{-2}}$, mass fluxes ranging from 200 to 600 $\mathrm{kg\,m^{-2}\,s^{-1}}$, a saturation temperature of 10 °C, and quality up to 1.0. The test section was made of stainless steel tubes with inner diameters of 1.5 mm and 3.0 mm, and a length of 2000 mm. The section was heated uniformly by applying an electric current to the tubes directly. Nucleate boiling heat transfer was the main contribution, particularly at the low quality region. An increasing and decreasing heat transfer coefficient occurred at the lower vapour quality with increasing heat flux and mass flux. The mean heat transfer coefficient ratio of R-22:R-134a:CO_2 was approximately 1.0:0.8:2.0. Laminar flow was observed in the minichannels. A new boiling heat transfer coefficient correlation based on the superposition model for refrigerants in minichannels was developed with a mean deviation of 11.21%.

08/01323 Calculation of neutron importance function in fissionable assemblies using Monte Carlo method

Feghhi, S. A. H. *et al. Annals of Nuclear Energy*, 2007, 34, (6), 514–520.

The purpose of the present work is to develop an efficient solution method for the calculation of neutron importance function in fissionable assemblies for all criticality conditions, based on Monte Carlo calculations. The neutron importance function has an important role in perturbation theory and reactor dynamic calculations. Usually this function can be determined by calculating the adjoint flux while solving the adjoint weighted transport equation based on deterministic methods. However, in complex geometries these calculations are very complicated. In this article, considering the capabilities of MCNP code in solving problems with complex geometries and its closeness to physical concepts, a comprehensive method based on the physical concept of neutron importance has been introduced for calculating the neutron importance function in sub-critical, critical and super-critical conditions. For this purpose a computer program has been developed. The results of the method have been benchmarked with ANISN code calculations in 1 and 2 group modes for simple geometries. The correctness of these results has been confirmed for all three criticality conditions. Finally, the efficiency of the method for complex geometries has been shown by the calculation of neutron importance in miniature neutron source reactor research reactor.

08/01324 Calculation of the critical point for mixtures using mixture models based on Helmholtz energy equations of state

Akasaka, R. *Fluid Phase Equilibria*, 2008, 263, (1), 102–108.

This paper mainly focuses on refrigerant mixtures with relatively simple critical behaviour, and presents a practical and useful method for the critical point calculation for the mixtures using mixture models based on Helmholtz energy equations of state. The expression for critical point criterion suitable for this objective is derived first. Numerical manipulations to obtain a physically correct solution are described in detail. For four binary refrigerant mixtures of difluoromethane (R-32) + pentafluoroethane (R-125), R-125 + 1,1,1,2-tetrafluoroethane (R-134a), R-125 + 1,1,1-trifluoroethane (R-143a), and R-32 + propane (R-290), the critical temperatures and critical molar volumes are calculated applying the presented method. The calculation results are compared with experimental values, and the capabilities of the mixture models for the mixtures in the critical region are discussed.

08/01325 Extrapolation of short-term creep rupture data – the potential risk of over-estimation

Dimmler, G. *et al. International Journal of Pressure Vessels and Piping*, 2008, 85, (1–2), 55–62.

This work deals with the creep behaviour of 9–12% Cr steels in the steady-state (secondary) creep regime in order to enable a more detailed and exact description of the creep rupture strength on the basis of the Monkman–Grant relation. The stationary creep behaviour has been investigated by evaluating the creep rate and the change of stress exponent of established grades of high temperature creep resistant steels using the so-called back-stress concept. A change in creep mechanism with applied stress is clearly identified in the creep rupture curves. The impact of this change is discussed and the huge potential for over-estimation of creep strengths from extrapolated short-term creep rupture data is emphasized.

08/01326 Heat transfer analysis for shell-and-tube heat exchangers with experimental data by artificial neural networks approach

Xie, X. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 1096–1104.
This work applied artificial neural network (ANN) for heat transfer analysis of shell-and-tube heat exchangers with segmental baffles or continuous helical baffles. Three heat exchangers were experimentally investigated. Limited experimental data was obtained for training and testing neural network configurations. The commonly used back propagation algorithm was used to train and test networks. Prediction of the outlet temperature differences in each side and overall heat transfer rates were performed. Different network configurations were also studied by the aid of searching a relatively better network for prediction. The maximum deviation between the predicted results and experimental data was less than 2%. Comparison with correlation for prediction shows superiority of ANN. It is recommended that ANN can be used to predict the performances of thermal systems in engineering applications, such as modelling heat exchangers for heat transfer analysis.

08/01327 Inverse determination of thermal conductivity by differential quadrature method

Char, M.-I. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (2), 113–119.
The differential quadrature method (DQM) is employed to inverse determination of thermal conductivity in one-dimensional slab. Several examples including spatially dependent and temperature dependent thermal conductivities are solved to illustrate the accuracy and efficiency of the DQM. The advantages of this approach are that no a priori assumption is made on the functional form of the estimates, and that the estimated thermal conductivity can be obtained directly in the calculating process. Of interest are the effects of the number of the measurement points and magnitude of measurement errors on the accuracy of the estimations. Comparisons are made between the estimated thermal conductivities and exact forms, and the agreement is found out to be generally good. Numerical results demonstrate that the DQM is effective and stable in treating this type of problem.

08/01328 Measurements on rotating blades using IR thermography

Mori, M. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (2), 387–396.
This paper presents an experimental and CFD numerical study of convective heat transfer and flow field characteristics in a rotating rotor cascade. Surface temperature distribution on a rotating heated blade was measured by means of infrared thermography, which proved highly advantageous over standard temperature sensors due to its completely non-intrusive nature. The experimental facility, IR thermography method, and the CFD numerical model that was made according to the actual test rig geometry and operating conditions, are described in detail. For the present study, tests were carried out in an iposonic flow regime at relatively low fluid temperatures, with the Rotational number varied and hot-to-cool air mass flow ratio and Reynolds number kept constant. Experimental and numerical results for the blade pressure side were found to be in good agreement. Analysis of the results focused on the influence of rotation and black paint thermal conductivity on heat transfer through the blade. The results, presented in terms of Nusselt number distribution along the blade midspan, show the influence of rotational number on convective heat transfer. Interpretation of numerical results showed that the black paint coating imposes additional thermal resistance to heat conduction, which can affect temperature distribution on the painted surfaces. With increasing rotational number and all other influential parameters kept constant, heat transfer intensifies, which is reflected in increased Nusselt numbers along the blade midspan.

08/01329 Modified-Levermore–Pomraning equation: its derivation and its limitations

Akcasu, A. Z. *Annals of Nuclear Energy*, 2007, 34, (7), 579–590.
A transport equation for the *mean* flux in spatially random media is derived, and is referred to as Modified-Levermore–Pomraning equation (M-L–P). It differs from the conventional L–P equations in that $|\mu|$ in the latter is replaced by μ in M-L–P. It is shown that when scattering is present the L–P equations are always incorrect in the sense there is not any special situation in which they can lead to an exact result. In particular they always predict the relaxation lengths of the spatial modes incorrectly. On the other hand, the M-L–P equations are exact when the flux at the origin is deterministic, as in some special cases such as half-infinite medium, and infinite medium with a localized source at the origin, when the density of the medium is spatially random. However, the M-L–P equations become approximate when the medium is a finite slab because of the right boundary condition. But the relaxation rates of the spatial modes are always calculated exactly even in finite slab. The nature of approximation inherent in the M-L–P is elucidated by comparison with the exact 'stochastic transition matrix formalism' developed earlier in two-stream transport.

08/01330 Non-Fourier heat conduction in a finite medium with insulated boundaries and arbitrary initial conditions

Moosaie, A. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (1), 103–111.
The non-Fourier transient heat conduction in a finite medium with insulated boundaries under the influence of arbitrary initial conditions is investigated analytically. The solution is expressed in the form of Fourier cosine series. The obtained analytical closed-form solution can be used for validation of numerical solutions. The resulting solution is valid for any choice of integrable initial conditions. The significant feature of proposed solution is its generality. In order to show the applicability of the presented solution, two numerical examples are solved.

08/01331 Numerical analysis of natural convection for a porous rectangular enclosure with sinusoidally varying temperature profile on the bottom wall

Varol, Y. *et al. International Communications in Heat and Mass Transfer*, 2008, 35, (1), 56–64.
Numerical investigations of steady natural convection flow through a fluid-saturated porous medium in a rectangular enclosure with a sinusoidal varying temperature profile on the bottom wall were conducted. All the walls of the enclosure are insulated except the bottom wall, which is partially heated and cooled. The governing equations were written under the assumption of Darcy-law and then solved numerically using finite difference method. The problem is analysed for different values of the Rayleigh number Ra in the range $10 \le \mathrm{Ra} \le 1000$, aspect ratio parameter AR in the range $0.25 \le \mathrm{AR} \le 1.0$ and amplitude λ of the sinusoidal temperature function in the range $0.25 \le \lambda \le 1.0$. It was found that heat transfer increases with increasing of amplitude λ and decreases with increasing aspect ratio AR. Multiple cells were observed in the cavity for all values of the parameters considered.

08/01332 Numerical study of flow anisotropy within a single natural rock joint

Giacomini, A. *et al. International Journal of Rock Mechanics and Mining Sciences*, 2008, 45, (1), 47–58.
The paper investigates the flow anisotropy within a natural joint subjected to mechanical shear. The cubic law is the simplest way to describe fluid flow through rock joints but because of rock wall roughness, deviations from this model have been observed. The Reynolds equation usually gives better results. In this study, micro-scale roughness is taken into account to define a reduced coefficient of permeability. Numerical simulations have been carried out by applying Darcy's law to the rock joint, described as an equivalent porous medium. The numerical simulations are based on experimental data obtained from a series of hydromechanical shear tests on a rock joint replica. The numerical results have been compared to the experimental ones, and to the results obtained by applying the Reynolds equation, to assess the relevance of the simulations. For the fracture studied, the approach proposed herein can reproduce relatively well the experimental flow anisotropy, and provides consistent values of flow rates, whereas the Reynolds equation tends to give higher flow rates.

08/01333 Rough set and fuzzy wavelet neural network integrated with least square weighted fusion algorithm based fault diagnosis research for power transformers

Dong, L. *et al. Electric Power Systems Research*, 2008, 78, (1), 129–136.
In this paper, a rough set and fuzzy wavelet neural network (FWNN), integrated with least square weighted fusion algorithm based fault diagnosis for power transformers, using dissolved gas analysis is proposed. This approach takes advantage of the knowledge reduction ability of rough set and good classified diagnosis ability of FWNN, integrated with least square (LS) weighted fusion algorithm. The rough set is used as a front of FWNN, integrated with LS weighted fusion algorithm to simplify the input of FWNN and mine the rules whose 'confidence' and 'support' satisfy a preset criteria. The mined rules are used as a diagnosis knowledge base to offer fault diagnosis service for power transformers. FWNN, integrated with LS weighted fusion algorithm, is used to diagnose the case that cannot be diagnosed by mined rules by rough set. The FWNN input is simplified by rough set reduction, and its learning rate is improved greatly. FWNN, integrated with LS weighted fusion algorithm, on one side, can much better improve the diagnosis accuracy, when the output vector of single FWNN has the similar element. On the other hand, its diagnosis accuracy cannot be limited by the neural network hidden layer number and correlated training parameter. The mechanism has good classified diagnosis ability. The advantages and effectiveness of this method are verified by testing.

08/01334 Scheme-selection optimization of cooling and heating sources based on exergy analysis

Gong, G. *et al. Applied Thermal Engineering*, 2007, 27, (5–6), 942–950.

Analysis method of product exergy cost has been presented for scheme-selection optimization of cooling and heating source system of air-conditioning system for buildings in this paper. And the product exergy cost is considered as the objective function by which to evaluate the air-conditioning cooling and heating sources system. Taking other related factors into consideration, the optimization algorithm for the air-conditioning cooling and heating source scheme-selection is brought forward. This optimization algorithm adopts an integrative, multiple objective decision method with the analysis of the product exergy cost. The algorithm essentially allows the air-conditioning cooling and heating source scheme-selection to be quantifiable. An example is presented to prove that the method is scientific and reliable.

08/01335 Systematic study of steam–water capillary pressure

Li, K. and Horne, R. N. *Geothermics*, 2007, 36, (6), 558–574.

Although steam–water capillary pressure is of central importance in geothermal reservoir engineering, it is nevertheless still poorly understood because of the difficulties involved in making direct measurements. To this end, some experimental and theoretical studies have been conducted. Unique methods have been developed to measure capillary pressures in order to overcome the complications in laboratory procedures associated with mass transfer as temperature and pressure changes. Both steam–water and air–water capillary pressures were measured and compared. Significant differences were found; in the cases studied, the steam–water capillary pressures were smaller. The drainage capillary pressure was greater than the imbibition capillary pressure, as was expected. Using experimental data, an empirical model was derived to calculate steam-water capillary pressure directly. Also developed was a generalized capillary pressure model based on fractal modelling of a porous medium; it encompasses the frequently used Brooks–Corey model as well as others. Recent studies on the topic are summarized and reviewed.

08/01336 The influence of a magnetic field on turbulent heat transfer of a high Prandtl number fluid

Nakaharai, H. *et al. Experimental Thermal and Fluid Science*, 2007, 32, (1), 23–28.

The influence of a transverse magnetic field on the local and average heat transfer of an electrically conducting, turbulent fluid flow with high Prandtl number was studied experimentally. The mechanism of heat transfer modification due to magnetic field is considered with aid of available numerical simulation data for turbulent flow field. The influence of the transverse magnetic field on the heat transfer was to suppress the temperature fluctuation and to steepen the mean temperature gradient in near-wall region in the direction parallel to the magnetic field. The mean temperature gradient is not influenced compared to the temperature fluctuation in the direction vertical to the magnetic field.

08/01337 Thermal analysis of energy crops. Part I: the applicability of a macro-thermobalance for biomass studies

Khalil, R. A. *et al. Journal of Analytical and Applied Pyrolysis*, 2008, 81, (1), 52–59.

In this work young shoots of poplar (*Populus euramericana*), tree of heaven (*Ailanthus altissima*) and pellets of a type of energy grass (*Agropyron*) were studied in order to get information about the applicability of these biomass materials for energy production by direct combustion. During the combustion of plant materials three main processes take place: (i) formation of volatiles, (ii) burning of volatiles and (iii) burn-off of the produced char. The thermal behaviour of the samples was studied with the help of a macro-thermobalance built at the Norwegian University of Science and Technology. Pyrolysis experiments have been performed in inert atmosphere to get a deeper insight into the formation of volatile products, whereas measurements in oxidative atmosphere have provided information about the burn-off of the samples, as well. In addition to monitoring the weight loss of the samples, the analysis of the evolved gases was carried out with gas chromatography (GC). The TG and DTG curves and the profiles of the evolved gases obtained in the pyrolysis experiments are similar in the case of the poplar and the tree of heaven samples implying that the thermal behaviour of these crops is alike, whereas those of the energy grass sample show significant differences. The decomposition of poplar occurs at a lower temperature in the presence of oxygen than that of energy grass. The evolution curves of the monitored products also exhibit differences. The results will be interpreted in terms of the chemical composition of the samples determined by proximate and ultimate analysis.

08/01338 Thermally dependent viscosity and non-Newtonian flow in a double-pipe helical heat exchanger

Rennie, T. J. and Vijaya Raghavan, G. S. *Applied Thermal Engineering*, 2007, 27, (5–6), 862–868.

A double-pipe helical heat exchanger was numerically studied to determine the effects of thermally dependent viscosity and non-Newtonian flows on heat transfer and pressure drop for laminar flow. Thermally dependent viscosities were found to have very little effect on the Nusselt number correlations for Newtonian fluids; however significant effects on the pressure drop in the heat exchanger were predicted. Changing the flow rate in the annulus can significantly affect the pressure drop in the inner tube, since the average viscosity of the fluid in the inner tube would change due to the change in the average temperature. The effects of non-Newtonian power law fluids on the heat transfer and the pressure drop were determined for laminar flow in the inner tube and in the annulus. The Nusselt number was correlated with the Péclet number for heat transfer in the inner tube. For the annulus, the Nusselt number was found to correlate best with the Péclet number and the curvature ratio. Pressure drop data were compared by using ratios of the pressure drop of the non-Newtonian fluid to a Newtonian fluid at identical mass flow rates and consistency indices.

08/01339 Unique supply function equilibrium with capacity constraints

Holmberg, P. *Energy Economics*, 2008, 30, (1), 148–172.

Consider a market where producers submit supply functions to a procurement auction with uncertain demand, e.g. an electricity auction. In the supply function equilibrium (SFE), every firm commits to the supply function that maximizes expected profit in the one-shot game given the supply functions of competitors. A basic weakness of the SFE is the presence of multiple equilibria. This paper shows that with (i) symmetric producers, (ii) perfectly inelastic demand, (iii) a price cap, and (iv) capacity constraints that bind with a positive probability, there exists a unique, symmetric SFE.

08/01340 Variational formulation of hyperbolic heat conduction problems applying Laplace transform technique

Saleh, A. and Al-Nimr, M. *International Communications in Heat and Mass Transfer*, 2008, 35, (2), 204–214.

In this paper, a non-Fourier heat conduction problem is analysed by employing newly developed theory. Application of conventional numerical schemes leads to strong oscillations of the results around discontinuities in solution domain. To overcome this difficulty the variational formulation of the Laplace-transformed hyperbolic heat conduction equation is developed. The results were used for evaluation of parameters used in approximate transformed temperature profiles. To validate the approach the results were compared with the exact analytical solution solved at special case and with an approach previously reported in the literature. Both showed a close agreement with the proposed approach.

08/01341 Young's modulus of some SOFCs materials as a function of temperature

Giraud, S. and Canel, J. *Journal of the European Ceramic Society*, 2008, 28, (1), 77–83.

Solid oxide fuel cells (SOFCs) have been under great consideration during this last decade and much effort has been dedicated to model their thermo-mechanical behaviour, trying to take into account the different properties of the materials, such as their elasticity. This paper reports the elastic behaviour of three classical materials used in SOFCs as a function of temperature: Yttria stabilized zirconia (YSZ), $La_{0.8}Sr_{0.2}MnO_3$ (LSM) and Ni-YSZ. Both YSZ and LSM present unusual behaviours. The elastic modulus of YSZ first decreases slowly up to 150 °C, then dramatically up to 550 °C (certainly due to atomic motion) and finally increases probably because of an order–disorder transition (oxygen vacancies). The state of the art on zirconia was reviewed. For the LSM material, Young's modulus could not be determined below 600 °C. Above this temperature, samples with totally closed porosity present a continuously increasing modulus, while the other samples have a quite constant modulus.

Fuel cell technology

08/01342 AC impedance technique in PEM fuel cell diagnosis – a review

Yuan, X. *et al. International Journal of Hydrogen Energy*, 2007, 32, (17), 4365–4380.

Because the AC impedance technique, also known as electrochemical impedance spectroscopy (EIS), is being utilized by more and more researchers in proton exchange membrane (PEM) fuel cell studies, the technique has developed into a primary tool in such research. In this paper the recent work on PEM fuel cells using the AC impedance technique is reviewed. Both *in situ* and *ex situ* impedance measurements are discussed, with primary focus on the *in situ* measurements. Within the domain of *in situ* studies, various methods for measuring the impedance of a PEM fuel cell are examined, and typical impedance spectra in several common scenarios are presented. Representative applications of the AC impedance technique in PEM fuel cell research are also discussed. Finally, the necessity of a time domain rapid AC impedance technique is briefly discussed.

08/01343 Constructal flow structure for a single SOFC

Ordonez, J. C. *et al. International Journal of Energy Research*, 2007, 31, (14), 1337–1357.

This paper presents a model and a structured procedure to optimize the internal structure of a single solid oxide fuel cell (SOFC) so that the power density is maximized. The polarization curve and power density are obtained as functions of temperature, geometry and operating parameters. The internal structure, which accounts for the thickness of the two electrodes and the electrolyte, and the flow channels geometry, has been optimized. The model is developed using a control volume approach, in which, all relevant thermal and electrochemical interactions between adjacent elements are accounted for. The effects of geometry on the compartments temperatures and reactants concentrations in the fuel cell are explored. The optimized internal structure results from optimal balances between the thickness of anode and cathode, L_3 and L_5, shoulder channel aspect ratio, L_t/L_{ch}, and the total number of fuel and oxidant channels, n_{ch}. The optima found are sharp and, therefore, important to be identified in actual SOFC design. The variations of power density in the studied ranges of L_3 and L_5, L_t/L_{ch}, and n_{ch} were of 11, 5 and 5%, respectively, in the three-way optimization process, for the anode-supported single SOFC.

08/01344 Dynamic modeling, design and simulation of a PEM fuel cell/ultra-capacitor hybrid system for vehicular applications

Uzunoglu, M. and Alam, M. S. *Energy Conversion and Management*, 2007, 48, (5), 1544–1553.

Fuel cell (FC) technologies are expected to become a viable solution for vehicular applications because they use alternative fuel converters and are environmentally friendly. However, a stand-alone FC system may not be sufficient to satisfy the load demands, especially during cold start, peak demand periods or transient events, for vehicular applications. In addition, the FC system is not capable of being reversed for regenerative energy. An ultra-capacitor (UC) bank can supply a large burst of power but cannot store much energy. By operating the FC and UC in parallel, both steady state and peak power demands can be satisfied. Use of a FC/UC hybrid model provides a potential solution for better energy efficiency while reducing the cost of FC power technology. This paper describes a new modelling and design methodology for FC/UC hybrid vehicular power systems. A feasible design and a dynamic model have been presented for the proposed technique. Simulation results are presented, using the MATLAB®, Simulink® and SimPowerSystems® environments, based on the mathematical and electrical models of the proposed system.

08/01345 Estimation of the effective thermal conductivity of carbon felts used as PEMFC gas diffusion layers

Ramousse, J. *et al. International Journal of Thermal Sciences*, 2008, 47, (1), 1–6.

Thermal conductivity of gas diffusion layers (GDL) used in fuel cells is a key parameter for the analysis of heat transfer in membrane electrodes assembly (MEA). This paper focuses on non-woven carbon felts. Although correlations are available, the felts thermal conductivity is difficult to estimate due to the nature of heat transfer in porous and fibrous materials: the effective conductivity of the solid phase is roughly known and the correlations giving effective conductivity of porous media (solid and fluid phases) have restricted range of application. Consequently, the authors chose to associate an analytical and an experimental approach. Their results converge and clearly show that the majority of values encountered in the literature are, most probably, highly overestimated.

08/01346 Experiment and simulation investigations for effects of flow channel patterns on the PEMFC performance

Ferng, Y.-M. *et al. International Journal of Energy Research*, 2008, 32, (1), 12–23.

Experiments and simulations are presented in this paper to investigate the effects of flow channel patterns on the performance of proton exchange membrane fuel cell (PEMFC). The experiments are conducted in the Fuel Cell Centre of Yuan Ze University and the simulations are performed by way of a three-dimensional full-cell computational fluid dynamics model. The flow channel patterns adopted in this study include the parallel and serpentine flow channels with the single path of uniform depth and four paths of step-wise depth, respectively. Experimental measurements show that the performance (i.e. cell voltage) of PEMFC with the serpentine flow channel is superior to that with the parallel flow channel, which is precisely captured by the present simulation model. For the parallel flow channel, different depth patterns of flow channel have a strong influence on the PEMFC performance. However, this effect is insignificant for the serpentine flow channel. In additional, the calculated results obtained by the present model show satisfactory agreement with the experimental data for the PEMFC performance under different flow channel patterns. These validations reveal that this simulation model can supplement the useful and localized information for the PEMFC with confidence, which cannot be obtained from the experimental data.

08/01347 Glass–ceramic seal to join Crofer 22 APU alloy to YSZ ceramic in planar SOFCs

Smeacetto, F. *et al. Journal of the European Ceramic Society*, 2008, 28, (1), 61–68.

This work describes the design and development of a glass–ceramic seal to produce a hermetic joint between the ceramic electrolyte and the metallic interconnect of planar SOFC stacks. The glass–ceramic composition was designed considering the chemical compatibility with the ceramic electrolyte (yttria stabilized zirconia) and the oxidation resistant metal alloy interconnect (Crofer 22 APU), the thermo-mechanical properties (characteristic temperatures, thermal expansion coefficient), and the wettability on the substrates. The designed glass–ceramic seal is a barium-free silica-based glass, which partially crystallizes during the heat treatment after being deposited on Crofer 22 APU substrate by slurry coating or by electrophoretic deposition. The sealing process of the glass–ceramic was optimized, also taking into account that the maximum processing temperature should be lower that 950 °C (upper limit for the metallic interconnect) and the maximum heating rate of about 5 °C/min (limit for ceramic components). The joined ceramic/seal/metal samples were morphologically characterized and preliminary tested for 400 h in air atmosphere at the fuel cell operating temperature of 800 °C. Thermal ageing in air caused a Cr-diffusion from Crofer 22 APU alloy to the seal only when the alloy was used in the as-received condition. The preoxidized one did not diffuse Cr ions through the seal under the same ageing conditions.

08/01348 Investigation of membrane electrode assembly (MEA) hot-pressing parameters for proton exchange membrane fuel cell

Therdthianwong, A. *et al. Energy*, 2007, 32, (12), 2401–2411.

The hot-pressing conditions for fabricating the membrane electrode assembly (MEA) of a proton exchange membrane fuel cell was investigated by using a $2n$ full factorial design. Time, temperature and pressure were key parameters that were varied from 500 to 1500 psi, 1 to 5 min and 100 to 160 °C, respectively. The results from the full factorial analysis indicated that the order of significance of the main MEA fabricating effects was temperature, pressure, time–temperature interaction and pressure–time–temperature interaction. By examining the cell performance curves, the lower fabrication conditions of temperature and pressure were suitable for MEA preparation. The conductive layer between the membrane and the catalyst layer became thin at high pressure and high temperature, as seen from scanning electron microscopy images. In the ranges of condition studied, the most suitable hot-pressing condition for MEA fabrication was at 100 °C, 1000 psi and 2 min. This condition provided the highest maximum power density from the MEA and the best contact at the interfaces between the gas diffusion layer, the active layer and the electrolyte membrane. The experimental results were verified by testing with a commercial MEA in the same operating condition and with the same equipment. The performance of the fabricated MEA was better than that of the commercial one.

08/01349 Investigation of resided water effects on PEM fuel cell after cold start

Castaldi, M. J. and Dooher, J. P. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4503–4509.

The effects of the residual water in the PEM fuel cell after cold start on the performance, electrode electrochemical characteristics, and cell components were investigated by controlling the cold-start processes of three cells at −5 °. Neither the cell performance loss nor the cell resistance increase with the start number was observed. There was no change in the electrochemical active surface area (ECA) and charge transfer resistance at low current density. The correlation between the amount of the residual water and the ohmic polarization and cell resistance showed mass-transport process slightly changed with the water amount in the cell. This trend correlated well with the charge transfer resistance at high current density. The change of mass-transport process came from the gas diffusion layer by the analysis of ECA. It was found that hydrogen crossover rate of the membrane at the three hydrated states did not change through eight start-ups at

−5°. Based on the analysis of SEM and water-storage capacity, it was believed that less water was stored in the catalyst layer even though much water resided in the cell.

08/01350 Microstructure and property evaluation of barium aluminosilicate glass–ceramic sealant for anode-supported solid oxide fuel cell

Ghosh, S. *et al. Journal of the European Ceramic Society*, 2008, 28, (1), 69–76.

Several glass compositions based on the barium aluminosilicate system have been investigated for their application as sealant for solid oxide fuel cell (SOFC). The developed glasses were characterized through measurement of different properties, viz. coefficient of thermal expansion (CTE), glass transition temperature (T_g), dilatometric softening temperature (T_d), crystallization behaviour during prolonged heat-treatment, electrical resistivity measurement, microstructural studies, etc. In addition, bonding behaviour between zirconia electrolyte and metallic interconnect in sandwiched condition has also been investigated to find out their suitability as sealant for SOFC. Microstructural investigation revealed a well-adhered bonding between the electrolyte and the metallic interconnect. The optimized glass composition also showed a high resistivity ($10^5\,\Omega$cm) at the SOFC operation temperature (∼800 °C).

08/01351 Parametric study of solid oxide fuel cell performance

Ni, M. *et al. Energy Conversion and Management*, 2007, 48, (5), 1525–1535.

An electrochemical model was developed to study the current–voltage (*J–V*) characteristics of a solid oxide fuel cell (SOFC). The Butler–Volmer equation, Fick's model and Ohm's law were used to determine the activation, concentration and ohmic overpotentials, respectively. One important feature of this model is that both the exchange current density and gas diffusion coefficients were dependent on the cell microstructures (porosity and pore size) and operational parameters (temperature, pressure and gas composition). The simulation results were compared with experimental data from the literature, and good agreement was obtained. The subsequent parametric modelling analyses determined how individual overpotentials were related to the geometric and operational parameters. It was found that there existed optimal values of electrode pore size and porosity for maximum cell performance. Both the activation and ohmic overpotentials decreased significantly with increasing temperature. However, the concentration overpotential was found to increase with increasing temperature. This unexpected phenomenon was caused by the reduced gas density at elevated temperature despite the increase in diffusion coefficient with increasing temperature. Besides, increasing the hydrogen content in the fuel stream and increasing the operating pressure were possible ways to enhance the SOFC power output. The parametric analyses provided insights in the operation of SOFCs and clarified some ambiguous understanding of SOFC overpotentials. The present model could also serve as a valuable tool for SOFC optimization design.

08/01352 Surface technologies 2006 – alternative energies and policy options

Rose, L. *Energy Policy*, 2007, 35, (12), 6106–6111.

Surfaces are the immediate contact between anything in the world. Literally, every industry utilizes coatings and surface modifications in order to create surfaces tailored to specific needs, protect underlying substrates, or modify their behaviour. Surface and coating technologies are essential to a large variety of different industrial sectors, including transportation, manufacturing, food and biomedical engineering, energy, resources, and materials science and technology. The present paper explains the limitations for alternative energy technologies, with a focus on fuel cell technology development and the alternative energy sector, based on the outcomes of presentations and facilitated discussion groups during a Canadian national workshop series. Options for technological improvements of alternative energy systems are presented in combination with national and international policy choices, which could positively influence research and development in the alternative energy sector.

08/01353 The effects of non-uniform distribution of catalyst loading on polymer electrolyte membrane fuel cell performance

Roshandel, S. and Farhanieh, L. *International Journal of Hydrogen Energy*, 2007, 32, (17), 4424–4437.

The catalyst layers are the most important part of the polymer electrolyte membrane (PEM) fuel cells, and the cell performance is highly related to its structure. The gas diffusion layers (GDLs) are also the essential components of the PEM fuel cell since the reactants should pass through these layers. Model prediction shows that electrical current in catalyst layer is non-uniform, influenced by the channel-land geometry. In addition, the compression effect of GDLs and water generation due to the electrochemical reaction may cause non-uniformity in porosity and, therefore, increases the non-uniformity in reactant concentration in GDL/catalyst layer interface. Simulation results suggest that non-uniform catalyst loading distribution in the catalyst layer will improve the performance of the whole catalyst layer by diminishing the variation in current density. In the present study the porosity variation in GDL is calculated by considering the applied pressure and the amount of water generated in the cell. The catalyst layer is described in terms of a spherical agglomerate model, and the effects of different mechanisms of water transport in membrane are investigated as well. The validity of the model is assessed by comparing the computed results with experimental data.

08/01354 Three dimensional analysis of planar solid oxide fuel cell stack considering radiation

Tanaka, T. *et al. Energy Conversion and Management*, 2007, 48, (5), 1491–1498.

The authors have been engaged in numerical simulations of the planar type solid oxide fuel cell (SOFC) to make clear the dependence of the cell performance on its operating conditions. Up to now, the authors have already developed the simulation codes for the one channel region and the single cell plate in its cell stack. To calculate accurately the effect of radiation heat transfer from the cell stack surfaces, however, a code that can treat the whole cell stack is necessary. In the present study, therefore, the authors newly develop a three-dimensional simulation code of the planar SOFC stack, and the detailed effect of the radiation heat transfer is investigated. It is made clear that the conventional codes are sufficiently accurate, and the newly developed whole cell stack code is not inevitable to predict the maximum cell temperature. This is because the thermal conductivity of the cell materials made of ceramics is very small, and the central part of the cell stack is almost free from the influence of radiation heat transfer. On the other hand, the stack simulation is needed to calculate accurately the cell voltage because the radiation heat transfer reduces it when the ambient temperature is low. The bad influence of low ambient temperature on the voltage is, however, small and relatively high voltage is obtained even when the ambient temperature is very low.

15 ENVIRONMENT

Pollution, health protection, applications

08/01355 A participatory systems approach to modeling social, economic, and ecological components of bioenergy

Buchholz, T. S. *et al. Energy Policy*, 2007, 35, (12), 6084–6094.

Availability of and access to useful energy is a crucial factor for maintaining and improving human well-being. Looming scarcities and increasing awareness of environmental, economic, and social impacts of conventional sources of non-renewable energy have focused attention on renewable energy sources, including biomass. The complex interactions of social, economic, and ecological factors among the bioenergy system components of feedstock supply, conversion technology, and energy allocation have been a major obstacle to the broader development of bioenergy systems. For widespread implementation of bioenergy to occur there is a need for an integrated approach to model the social, economic, and ecological interactions associated with bioenergy. Such models can serve as a planning and evaluation tool to help decide when, where, and how bioenergy systems can contribute to development. One approach to integrated modelling is by assessing the sustainability of a bioenergy system. The evolving nature of sustainability can be described by an adaptive systems approach using general systems principles. Discussing these principles reveals that participation of stakeholders in all components of a bioenergy system is a crucial factor for sustainability. Multi-criteria analysis is an effective tool to implement this approach. This approach would enable decision-makers to evaluate bioenergy systems for sustainability in a participatory, transparent, timely, and informed manner.

08/01356 Disconnect between the Philippine mining investment policy and indigenous people's rights

Holden, W. and Ingelson, A. *Journal of Energy and Natural Resources Law*, 2007, 25, (4), 375–391.

Throughout the world, conflict arising from mineral development in areas occupied by indigenous peoples is common. The Philippines is well endowed with mineral resources. The government's policy to encourage mineral development ignores the rights provided to indigenous peoples in the Indigenous Peoples' Right Act (IPRA). This mining-based development paradigm has prompted opposition to mineral development from indigenous peoples. The conflict has entailed disputes involving the mining industry, government and indigenous peoples concerning environmental impacts, the validity of IPRA and alleged human rights abuses.

08/01357 Ecological efficiency in thermoelectric power plants

de Castro Villela, I. A. and Silveira, J. L. *Applied Thermal Engineering*, 2007, 27, (5–6), 840–847.

This work evaluates the environmental impact resulting from the natural gas and diesel combustion in thermoelectric power plants that utilize the combined cycle technology (CC), as regarding to Brazilian conditions according to Thermopower Priority Plan (TPP). In the regions where there are not natural gas the option has been the utilization of diesel and consequently there are more emission of pollutants. The ecological efficiency concept, which evaluates by and large the environmental impact, caused by CO_2, SO_2, NO_x and particulate matter (PM) emissions. The combustion gases of the thermoelectric power plants working with natural gas (less pollutant) and diesel (more pollutant) cause problems to the environment, for their components harm the human being life, animals and directly the plants. The resulting pollution from natural gas and diesel combustion is analysed, considering separately the CO_2, SO_2, NO_x and particulate matter gas emission and comparing them with the in use international standards regarding the air quality. It can be concluded that it is possible to calculate thermoelectric power plant quantitative and qualitative environment factor, and on the ecological standpoint, for plant with total power of 41,441 kW, being 27,170 kW for the gas turbine and 14,271 kW for the steam turbine. The natural gas used as fuel is better than the diesel, presenting ecological efficiency of 0.944 versus 0.914 for the latter, considering a thermal efficiency of 54% for the combined cycle.

08/01358 Energy-related emissions and mitigation opportunities from the household sector in Delhi

Kadian, R. *et al. Energy Policy*, 2007, 35, (12), 6195–6211.

Urban centres are the major consumers of energy, which is a major source of air pollution. Therefore, an insight into energy consumption and quantification of emissions from urban areas are extremely important for identifying impacts and finding solution to air pollution in urban centres. This paper applies the long-range energy alternatives planning system for modelling the total energy consumption and associated emissions from the household sector of Delhi. Energy consumption under different sets of policy and technology options are analysed for a time span of 2001–2021 and emissions of carbon dioxide, carbon monoxide, methane, non-methane volatile organic compounds, nitrogen oxides, nitrous oxide, total suspended particulates and sulfur dioxide are estimated. Different scenarios are generated to examine the level of pollution reduction achievable by application of various options. The business as usual scenario is developed considering the time series trends of energy use in Delhi households. The fuel substitution (FS) scenario analyses policies having potential to impact fuel switching and their implications towards reducing emissions. The energy conservation (EC) scenario focuses on efficiency improvement technologies and policies for energy-intensity reduction. An integrated scenario is also generated to assess the cumulative impact of the two alternate scenarios on energy consumption and direct emissions from household sectors of Delhi. Maximum reduction in energy consumption in households of Delhi is observed in the EC scenario, whereas, the FS scenario seems to be a viable option if the emission loadings are to be reduced.

08/01359 Experimental study of various effects of exhaust gas recirculation (EGR) on combustion and emissions of an automotive direct injection diesel engine

Maiboom, A. *et al. Energy*, 2008, 33, (1), 22–34.

Cooled exhaust gas recirculation (EGR) is a common way to control in-cylinder NO_x production and is used on most modern high-speed direct injection (HSDI) diesel engines. However EGR has different effects on combustion and emissions production that are difficult to distinguish (increase of intake temperature, delay of rate of heat release (ROHR), decrease of peak heat release, decrease in O_2 concentration (and thus of global air/fuel ratio (AFR)) and flame temperature, increase of lift-off length, etc.), and thus the influence of EGR on NO_x and particulate matter (PM) emissions is not perfectly understood, especially under high EGR rates. An experimental study has been conducted on a 2.01 HSDI automotive diesel engine under low-load and part load conditions in order to distinguish and quantify some effects of EGR on combustion and NO_x/PM emissions. The increase of inlet temperature with EGR has contrary effects on combustion and emissions, thus sometimes giving opposite tendencies as traditionally observed, as, for example, the reduction of NO_x emissions with increased inlet temperature. For a purely diffusion combustion the ROHR is unchanged when the AFR is maintained when changing in-cylinder ambient gas properties (temperature or EGR rate). At low-load conditions, use of high EGR rates at constant boost pressure is a way to drastically reduce NO_x and PM emissions but with an increase of brake-specific fuel consumption (BSFC) and other emissions (CO and hydrocarbon), whereas EGR at constant AFR may drastically reduce NO_x emissions without important penalty on BSFC and soot emissions but is limited by the turbocharging system.

08/01360 Impact assessment procedures for sustainable development: a complexity theory perspective

Nooteboom, S. *Environmental Impact Assessment Review Environmental Impact Assessment Review*, 2007, 27, (7), 645–665.

The author assumes that effective impact assessment procedures should somehow contribute to sustainable development. There is no widely agreed framework for evaluating such effectiveness. The author suggests that complexity theories may offer criteria. The relevant question is 'do impact assessment procedures contribute to the 'requisite variety' of a social system for it to deal with changing circumstances?' Requisite variety theoretically relates to the capability of a system to deal with changes in its environment. The author reconstructs how thinking about achieving sustainable development has developed in a sequence of discourses in The Netherlands since the 1970s. Each new discourse built on the previous ones, and is supposed to have added to 'requisite variety'. The author asserts that impact assessment procedures may be a necessary component in such sequences and derives possible criteria for effectiveness.

08/01361 Lessons learned in remediation and restoration in the Oklahoma prairie: a review

Sublette, K. L. *et al. Applied Geochemistry*, 2008, 22, (10), 2225–2239.

For almost a decade the Tallgrass Prairie Preserve in Oklahoma has been used as a field laboratory for the investigation of aspects of the remediation and restoration of oil and brine spills. Objectives of this work have included: (1) simplification of the remediation process and lowering the cost of remediation; (2) the development of methods to accelerate or jump-start the restoration process; and (3) determining appropriate metrics for assessing the status of soil ecosystem recovery. This research has resulted in a number of lessons learned that will be presented here which can be exported to other exploration and production sites, especially sites located in sensitive ecosystems. Key observations have included the role of a fertilizer amendment in linking the remediation and restoration process at an oil-impacted site, the use of nematodes as ecological indicators in the restoration of oil- and brine-impacted sites, and the development of a two-stage process for remediation of brine impacted sites that does not include significant use of gypsum.

08/01362 Managing the potential public health risks from bioaerosol liberation at commercial composting sites in the UK: an analysis of the evidence base

Sykes, P. *et al. Resources, Conservation and Recycling*, 2007, 52, (2), 410–424.

The diversion of biodegradable waste from landfill is of key importance in developing a sustainable waste strategy for the next decade and beyond. The proliferation of waste treatment technologies such as mechanical biological treatment, anaerobic digestion and composting will be paramount in achieving this strategic goal. This paper evaluates the scientific information needed to undertake an effective assessment of the potential public health risks from exposure to bioaerosols in the vicinity of commercial composting activities. Knowledge gaps currently exist in the scientific and regulatory community that limit the ability to effectively characterize source-term emissions, develop reliable dose–response data and accurately model the dispersion of bioaerosols. Consequently reliable risk estimates cannot be developed to inform the management of these potential risks. This uncertainty may prove a barrier to progress in achieving waste diversion and composting targets in Wales and the rest of the UK. A robust and extensive evidence base is required to inform the risk assessment process. This paper advocates the need for further, more focused research into hazard characterization of viable and non-viable organisms, improved dose–response data, exposure assessment techniques and an evaluation of the existing risk control and mitigation measures currently adopted. It is hoped that his will enable effective, timely and proportional risk management and mitigation measures to be developed that will foster the confidence required in composting technologies to achieve waste diversion targets and develop sustainable waste strategies.

08/01363 Measuring environmental performance under different environmental DEA technologies

Zhou, P. *et al. Energy Economics*, 2008, 30, (1), 1–14.

Data envelopment analysis (DEA) efficiency measures integrated with the environmental DEA technology have gained popularity in environmental performance measurement. Most studies assume that the environmental DEA technology exhibits constant returns to scale. In this paper the authors further discuss the environmental DEA technologies that exhibit non-increasing returns to scale and variant returns to scale (VRS). The pure measures under different situations and a mixed measure under the VRS environmental DEA technology for measuring environmental performance are proposed. For the measures that deal with nonlinear programming models, their linear programming equivalents are also given. Finally a study on measuring the carbon emission performance of eight world regions is presented.

08/01364 Nuclear corporate social responsibility: an approach toward a roadmap for gaining social confidence

Sawada, T. *et al. International Journal of Nuclear Governance, Economy and Ecology*, 2007, 1, (3), 265–277.

The term 'corporate social responsibility' (CSR) has been widely applied in the field of business administration. The essence of CSR is the idea, guidelines and methodology with regard to how a corporation can fulfil its responsibility to society. Recently, the concept and methodology of CSR, occasionally referred to as just SR, have also been applied to other organizations, such as research establishments and universities. A typical aspect of this trend is that most electric power companies publish CSR reports, which are an improved version of social environmental reports. CSR embodies the expectations of society with respect to how far the corporations and organizations, including universities, can resolve the issues in which society is necessarily involved or that can bring about advancements in society. Nuclear power generation and related facilities are types of 'societal systems', and not merely technological systems. Society commits its necessary functions to the societal systems.

08/01365 Recent progress on passive cooling techniques. Advanced technological developments to improve survivability levels in low-income households

Santamouris, M. *et al. Energy and Buildings*, 2007, 39, (7), 859–866.

Low-income households in developed and less developed countries suffer from serious indoor environmental problems such as heat stress, lack of comfort and poor indoor air quality. Passive cooling of buildings and in particular solar and heat protection techniques, heat dissipation and heat amortization techniques have reached a very high degree of maturity. New technological developments have proven extremely efficient in decreasing the need for cooling and improving indoor environmental conditions. Developments on the field of solar and heat protection, such as highly reflective coatings for the urban environment and the building envelope and new knowledge and developments on the field of ground and convective cooling and ventilation, may help low-income citizens to considerably improve their quality of life during the overheating period. These new developments are characterized by low cost and are easy to apply. This paper investigates the potential of the more promising new developments on the field of passive cooling, like the cool reflective coatings to improve outdoor and indoor conditions of low-income households in warm areas of the planet, ground cooling using earth to air heat exchangers, and discusses the potential of new ventilation techniques and systems for improving indoor comfort and air quality. Results show a very high potential to improve indoor environmental conditions and contribute towards higher passive survivability levels.

08/01366 Reducing radiotoxicity in the long run

Westlén, D. *Progress in Nuclear Energy*, 2007, 49, (8), 597–605.

Stockpiles of spent nuclear fuel and weapons material are growing worldwide. So far, the only long-term strategy seriously considered is geological repository for several hundred thousand years. Transmutation is an option significantly reducing the time during which repositories have to be sealed, simplifying the task of protecting future generations from the radioactive remnants of our civilization. This paper gives an overview of motives and priorities, and describes the main technique suggested for transmutation of nuclear waste.

08/01367 Soil carbon, after 3 years, under short-rotation woody crops grown under varying nutrient and water availability

Sanchez, F. G. *et al. Biomass and Bioenergy*, 2007, 31, (11–12), 793–801.

Soil carbon contents were measured on a short-rotation woody crop study located on the US Department of Energy's Savannah River Site outside Aiken, SC. This study included fertilization and irrigation treatments on five tree genotypes (sweetgum, loblolly pine, sycamore and two eastern cottonwood clones). Prior to study installation, the previous pine stand was harvested and the remaining slash and stumps were pulverized and incorporated 30 cm into the soil. One year after harvest soil carbon levels were consistent with pre-harvest levels but dropped in the third year below pre-harvest levels. Tillage increased soil carbon contents, after three years, as compared with adjacent plots that were not part of the study but where harvested, but not tilled, at the same time. When the soil response to the individual treatments for each genotype was examined, one cottonwood clone (ST66), when irrigated and fertilized, had higher total soil carbon and mineral associated carbon in the upper 30 cm compared with the other tree genotypes. This suggests that root development in ST66 may have been stimulated by the irrigation plus fertilization treatment.

08/01368 The environmental impact of decentralised generation in an overall system context

Haeseldonckx, D. and D'haeseleer, W. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 437–454.

Decentralized-generation technologies are very likely to play an important role in the future energy supply. The operational behaviour of several decentralized-generation technologies, as well as their interaction with the central power system, are being discussed and reviewed. The outcome of this analysis is then used to make correct judgements on the global environmental performance of the concept of embedded generation. In order to assess the environmental impact of a massive installation of decentralized-generation units, simulations are being performed using the code PROMIX, a very accurate model of the generation units presently existing (and anticipating those planned in the future) in Belgium. Finally, the simulation results are being discussed and some important conclusions about the environmental impact of decentralized generation can be drawn.

08/01369 Thermal comfort and workplace occupant satisfaction – results of field studies in German low energy office buildings

Wagner, A. *et al. Energy and Buildings*, 2007, 39, (7), 758–769.

The issues of comfort and workspace quality in buildings have gained much importance with the European 'Energy Performance of Buildings Directive' of 2001. New energy efficient building concepts and technologies require a revision of comfort standards, as these were originally developed for air-conditioned buildings only. Particularly, the question of recommendable upper indoor temperature limits needs further investigation. In addition, a broader approach to occupant satisfaction in buildings is necessary with respect to overall building performance. The results of a 4-week summer field study on thermal comfort with 50 subjects in a naturally ventilated office building in Karlsruhe, Germany, show that thermal sensation votes do not correspond to calculated predicted mean votes, but a very good agreement can be seen with adaptive comfort models. The dependence between thermal comfort and the outdoor temperature in naturally ventilated buildings could therefore be confirmed. A survey on workplace occupant satisfaction in 16 office buildings in Germany revealed that the occupants' control of the indoor climate and moreover the perceived effect of their intervention strongly influence their satisfaction with thermal indoor conditions. The paper also introduces a method for assessing the building performance by occupant surveys calculating the weighted importance of every satisfaction parameter in relation to the general acceptance of the workplace and then ranking the different satisfaction parameters.

08/01370 Thermal comfort in sub-Saharan Africa: field study report in Jos-Nigeria

Ogbonna, A. C. and Harris, D. J. *Applied Energy*, 2008, 85, (1), 1–11.

There is much documented material concerning human thermal comfort from the physiological, adaptive and social convention paradigms. Most of these studies have been conducted on limited-occupancy buildings, such as offices and institutions of higher learning in the northern hemisphere and parts of the ASEAN region; the subjects generally being adults and assumed to be in good health. In contrast, limited work appears to have been carried out in regularly occupied buildings like homes and in tropical sub-Saharan Africa. This study seeks to fill this gap by providing empirical thermal comfort data from a city in the tropical savannah region of Africa. The data collected include temperature, humidity, CO_2 level and lighting level, as well as results from questionnaires on the occupants' sensations of thermal comfort. The results show the range of conditions in which occupants in naturally ventilated buildings are comfortable. The preferred conditions suggested by the data are an operative temperature of just over 26 °C.

CO_2, NO_x, SO_2 and particulate emissions

08/01371 A detailed kinetic mechanism including methanol and nitrogen pollutants relevant to the gas-phase combustion and pyrolysis of biomass-derived fuels

Zabetta, E. C. and Hupa, M. *Combustion and Flame*, 2008, 152, (1–2), 14–27.

A detailed chemical kinetic mechanism for the simulation of the gas-phase combustion and pyrolysis of biomass-derived fuels was compiled by assembling selected reaction subsets from existing mechanisms (parents). The mechanism, here referred to as 'ÅA,' includes reaction subsets for the oxidation of hydrogen (H_2), carbon monoxide (CO), light hydrocarbons (C_1 and C_2), and methanol (CH_3OH). The mechanism also takes into account reaction subsets of nitrogen pollutants, including the reactions relevant to staged combustion, reburning, and selective noncatalytic reduction (SNCR). The ÅA mechanism was validated against suitable experimental data from the literature. Overall, the ÅA mechanism gave more accurate predictions than three other mechanisms of reference, although the reference mechanisms performed better occasionally. The predictions from ÅA were also found to be consistent with the predictions of its parent mechanisms within most of their range of validity, thus transferring the validity of the parents to the inheriting mechanism (ÅA). In parametric studies the ÅA mechanism predicted that the effect of methanol on combustion and pollutants is often similar to that of light hydrocarbons, but it also showed that there are important exceptions, thus suggesting that methanol should be taken into account when simulating biomass combustion. To the best of the authors' knowledge, the ÅA mechanism is currently the only mechanism that accounts for the chemistry of methanol and nitrogen relevant to the gas-phase combustion and pyrolysis of biomass-derived fuels.

08/01372 Abatement costs of SO_2-control options in the Mexican electric-power sector

Islas, J. and Grande, G. *Applied Energy*, 2008, 85, (2–3), 80–94.

Mexico's electricity-sector contributes over 75% of national SO_2-emissions, causing economic and health damage. These emissions come mostly from the combustion of fossil-fuels, whereas a minor share comes from biomass (wood fuel and sugar cane) burning emissions as well as those produced by industrial processes. For this reason, this study assesses the abatement costs of several SO_2-control options (including flue-gas desulfurization technologies, hydrotreatment of fuel oil, and the substitution of high-sulfur by low-sulfur content fuels). Likewise, this study has evaluated the implementation of such options in 10 selected power-plants – the main SO_2 emitters in the Mexican Electric Power Sector (MEPS) – with the aim of suggesting solutions for SO_2-emissions reduction and estimating the corresponding abatement, investment and total costs during the analysed period. Study's results indicate that the best SO_2-abatement-costs route may account for a reduction of 41% of MEPS SO_2-emissions and would require investment and total costs of \$841 and \$477 million, respectively. This means that an important reduction in the national SO_2-emissions may be achieved with a relatively small effort.

08/01373 Comparison of carbon monoxide emissions and electricity consumption of modulating and non-modulating pellet and solar heating systems

Fiedler, F. *et al. International Journal of Energy Research*, 2007, 31, (10), 915–930.

Emission and electricity consumption are important aspects of a pellet heating system. Low noxious emissions, particularly carbon monoxide, are a measure of a well-performing system. High carbon monoxide emissions are often caused by unnecessary cycling of the burner, poor adjustment of the combustion air and insufficient maintenance. The carbon monoxide output, the thermal performance and the electricity consumption for modulating and non-modulating operation mode have been investigated by simulations of four stoves/boilers as part of combined solar and pellet heating systems. The systems have been modelled with the simulation programme TRNSYS and simulated with the boundary conditions for space heating demand, hot water load and climate data as used in earlier research projects. The results from the simulations show that operating the pellet units with modulating combustion power reduces the number of starts and stops but does not necessarily reduce the carbon monoxide output. Whether the carbon monoxide output can be reduced or not depends very strongly on the reduction of starts and stops and how much the carbon monoxide emissions increase with decreased combustion power, which are in turn dependent on the particular settings of each pellet burner and how the heat is transferred to the building. However, for most systems the modulating operation mode ahs a positive impact on carbon monoxide emissions. Considering the total auxiliary energy demand, including the electricity demand of the pellet units, the modulating combustion control is advantageous for systems 1 and 4 for the used boundary conditions. The study also shows that an appropriate sizing of the stove or boiler has a huge potential for energy saving and carbon monoxide emission reduction.

08/01374 Emissions from the Polish power industry

Uliasz-Bochenczyk, A. and Mokrzycki, E. *Energy*, 2007, 32, (12), 2370–2375.

Poland is a country where power and heat energy production is based on conventional fuel combustion, above all hard coal and lignite. In power plants and combined heat and power plants, fossil fuel combustion results in emitting to the atmosphere first of all SO_2, NO_x, CO, particulate matter, greenhouse gases for instance N_2O and CO_2. For many years the Polish power industry has tried to reduce the emission of air contaminants to the atmosphere. The reduction is feasible on account of various methods of emission reduction, which have been advanced and applied for many years. The paper presents conventional fuels used in the Polish professional power industry, as well as the principal emission types occurring there for the last 10 years and the undertaken reduction measures.

08/01375 Energy-efficiency strategy for CO_2 emissions in a residential sector in Japan

Ashina, S. and Nakata, T. *Applied Energy*, 2008, 85, (2–3), 101–114.

This study examines the economics of energy-efficiency strategies, for reducing CO_2 emissions in a residential sector in Japan, from the perspective of regional characteristics. For this study, the residential sector in the Iwate prefecture was selected as representative of rural areas in Japan. In order to promote the purchases of energy-efficient consumer appliances, the prefectural government is presumed to reimburse purchasers a part of the cost difference between energy-efficient and conventional appliances. This paper begins with a discussion of the prefecture's financial support for purchasers of energy-efficient appliances and assumes that the payments come from prefectural government funds. This paper then looks at the effect of a carbon-tax refund on the reduction of CO_2 emissions. The results show that, if half of the households use energy-efficient appliances, then CO_2 emissions in the residential sector in the year 2020 will decreases from the BAU scenario of 0.726 Mt-C to 0.674 Mt-C. However, the Iwate prefectural government expends \$105 million annually, which is 1.5% of the total tax revenue for the year 2003. The carbon-tax refund effectively encourages further reductions in CO_2 emissions. Under the \$20/tC carbon-tax, proposed by the Ministry of the Environment, the carbon-tax refund leads to a reduction in residential CO_2 emissions from 0.726 Mt-C to 0.712 Mt-C.

08/01376 On the sources of technological change: what do the models assume?

Clarke, L. *et al. Energy Economics*, 2008, 30, (2), 409–424.

It is widely acknowledged that technological change can substantially reduce the costs of stabilizing atmospheric concentrations of greenhouse gases. This paper discusses the sources of technological change and the representations of these sources in formal models of energy and the environment. The paper distinguishes between three major sources of technological change – R&D, learning-by-doing and spillovers – and introduces a conceptual framework for linking modelling approaches to assumptions about these real-world sources. A selective review of modelling approaches, including those employing exogenous technological change, suggests that most formal models have meaningful real-world interpretations that focus on a subset of possible sources of technological change while downplaying the roles of others.

08/01377 The impacts of EU CO_2 emissions trading on electricity markets and electricity consumers in Finland

Kara, M. *et al. Energy Economics*, 2008, 30, (2), 193–211.

In this paper, the likely impacts of the EU emission trading system on the Nordic electricity market and on the position of various market actors are assessed. In its first phase, the EU CO_2 emission trading system includes power plants with thermal capacity greater than 20 MW, metals industry, pulp and paper industry, mineral industry and oil refineries. This paper describes the assessment done for the Finnish Minister of Trade and Industry, analysing the likely impacts on power plant operators, on energy-intensive industries, on other industries and on other consumer groups. The impacts of emissions trading were studied with the VTT electricity market model and with the TIMES energy system model. The annual average electricity price was found to rise 0.74 € $MW\,h^{-1}$ for every 1 € tonne CO_2^{-1} in the Nordic area. Large windfall profits were estimated to incur to electricity producers in the Nordic electricity market. In Finland, metals industry and private consumers were estimated to be most affected by the electricity market price increases. Expanded nuclear power generation could limit the increases in the prices of electricity to one-third compared to those in the base case.

Hydrocarbon emissions

08/01378 Co-firing coal with rice husk and bamboo and the impact on particulate matters and associated polycyclic aromatic hydrocarbon emissions

Chao, C. Y. H. *et al. Bioresource Technology*, 2008, 99, (1), 83–93.

The potential of co-firing rice husk and bamboo with coal was studied in a bench-scale pulverized fuel combustion reactor. Experimental parameters including biomass blending ratio in the fuel mixture, biomass grinding size, excess air ratio and relative moisture content in the biomass were investigated. Particulate matter (PM) in the forms of PM$_{10}$, PM$_{2.1}$, ultra fine particles as well as the associated polycyclic aromatic hydrocarbons (PAHs) emissions were evaluated. An operation range between 10% and 30% of biomass to coal ratio was found to be the optimum range in terms of minimum pollutant emissions per unit energy output. Co-combustion of coal with biomass seemed to have the effect of moving the fly-ash in PM$_{2.1}$ to a larger size range, but increasing the number counts of the ultra fine particles. It was noted that the much higher volatile matter content in the biomass fuels has played a key role in improving the combustion performance in the system. However, slagging, fouling and formation of clinker could be the issues requiring attention when using biomass co-combustion in conventional boilers.

08/01379 Decomposition of polycyclic aromatic hydrocarbons in atmospheric aqueous droplets through sulfate anion radicals: an experimental and theoretical study

Wang, D. *et al. Science of the Total Environment*, 2008, 393, (1), 64–71.

Polycyclic aromatic hydrocarbons (PAHs) are environmental pollutants that have received considerable attention because of their carcinogenic and mutagenic effects. PAHs can be degraded by sulfate anion radicals in atmospheric aqueous droplets. This study was to investigate the mechanism and degradation products of sulfate anion radical reaction with anthracene (ANT) by experimental and quantum chemical approaches. From these observations of the experiments, the sulfate anion radical is capable of oxidizing ANT rapidly and three intermediates anthraquinone (ATQ), 1-hydroxyanthraquinone (1-hATQ), and 1,4-dihydroxyanthraquinone (1,4-dhATQ) were detected as degradation products by GC-MS. The proposed one-electronic transfer mechanism of sulfate anion radical reaction with ANT was modelled using hybrid density function theory (BHandHLYP) methods. Geometry optimization and vibrational frequency analysis calculation were performed for reactants, transition states, intermediates, and products. The potential energy surfaces of these reactions are explored to establish structures and relative energies of reactants, intermediates, transition states, and products. Computational results suggest that initial electron transfer step is predicted to have activation energy of −3.35 kcal/mol in water, indicating that ANT can be oxidized quickly in atmospheric aqueous droplets. The reaction pathways have been proposed on the basis of these experimental and theoretical findings. The results may provide useful information for a better understanding of the sulfate anion radical-initiated reactions in atmospheric aqueous droplets such as clouds, rains or fogs.

08/01380 Microcosm experiments of oil degradation by microbial mats. II. The changes in microbial species

Llirós, M. *et al. Science of the Total Environment*, 2008, 393, (1), 39–49.

The influence of microbial mats on the degradation of two crude oils (Casablanca and Maya) and the effect of oil pollution on the mat structure were assessed using model ecosystems, prepared under laboratory conditions subject to tidal movements, from pristine Ebro Delta microbial-mat ecosystems. Both selected oils are examples of those currently used for commercial purposes. Casablanca crude oil is aliphatic with a low viscosity; Maya represents a sulfur-rich heavy crude oil that is predominantly aromatic. In the unpolluted microcosms, *Microcoleus chthonoplastes-*, *Phormidium*- and *Oscillatoria*-like were the dominant filamentous cyanobacterial morphotypes, whilst *Synechoccocus*-, *Synechocystis*- and *Gloeocapsa*-like were the most abundant unicellular cyanobacteria. After oil contamination, no significant changes of chlorophyll *a* and protein concentrations were observed, though cyanobacterial diversity shifts were monitored. Among filamentous cyanobacteria, *M. chthonoplastes*-like morphotype was the most resistant for both oils, unlike the other cyanobacteria, which tolerated Casablanca but not Maya. Unicellular cyanobacteria seemed to be resistant to pollution with both essayed oils, with the exception of the morphotype resembling *Gloeocapsa*, which was sensitive to both oils. The crude-oil addition also had a significant effect on certain components of the heterotrophic microbial community. Casablanca oil induced an increase in anaerobic heterotrophic bacteria, whereas the opposite effect was observed in those heterotrophs when polluted with Maya oil. The overall results, microbiological and crude-oil transformation analysis, indicate that the indigenous community has a considerable potential to degrade oil components by means of the metabolic cooperation of phototrophic and heterotrophic populations.

08/01381 Polycyclic aromatic hydrocarbons in road dust over Greater Cairo, Egypt

Hassanien, M. A. and Abdel-Latif, N. M. *Journal of Hazardous Materials*, 2008, 151, (1), 247–254.

Road dust samples were collected during 2005 and polycyclic aromatic hydrocarbons (PAHs) were determined. Sites under investigation were selected to represent the different parts of Greater Cairo, Egypt. Estimation and spatial distribution pattern of PAHs in road dust were the main objectives of this study. The road dust samples were collected from 17 sites over greater Cairo. The concentration of PAHs was determined by using HPLC technique. Twelve common environmental PAHs were found to be distributed. The present data illustrated that the total average of PAHs over the investigated sites was ranged from 0.045 to 2.6 mg/kg. On individual scale, the highest concentrations were 1.031 and 1.028 mg/kg for pyrene and phenanthrene, meanwhile the lowest was benzo(a)pyrene with value 0.0001 mg/kg. The obtained results showed that the carcinogenic content of PAHs (naphthalene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene and benzo(a)pyrene) ranged from 0.8 to 46.6% of total PAHs. It has been concluded from the present work that PAHs concentrations are greater and closer to traffic routes and industrial activities.

08/01382 The influence of rotary valve distribution systems on the energetic efficiency of regenerative thermal oxidizers

Amelio, M. *et al. International Journal of Energy Research*, 2008, 32, (1), 24–34.

On–off valve systems, commonly used in regenerative thermal oxidizer (RTO) plants, generate, during the opening time, a mass flow rate (MFR) which is constant. On the contrary, rotary valve systems, which are increasingly adopted in RTO plants, are characterized by variable MFR profiles. In this work, the energy requirements of two RTO systems, equipped with on–off or rotary valves, were determined using a home-developed numerical code. Energy performances were evaluated by calculating the thermal efficiency and pressure drop within structured or random packed bed RTO systems, at the same mean MFR. The results demonstrated that thermal efficiency was only moderately influenced by the valve system, and is slightly lower for the RTO with on–off valve. On the other hand, the study revealed that energy requirements of all RTO systems were basically unaffected by cycle duration, allowing valve rotational velocity to be freely set to maximize for other technical requirements. On the contrary, pressure drop was greatly influenced by the valve type and increased as variability in MFR function augmented. Moreover, the type of regenerator, structured or random packed bed, affected differently the total energy requirements (basically pumping energy plus auxiliary fuel). Energy requirements of structured and random regenerators were comparable only when volatile organic compounds concentration was lower than typical values encountered in the industrial practise. In other cases, structured regenerators RTO were more competitive. Finally, structured regenerators are usually the best choice when rotating valve distribution systems are adopted.

Life cycle analysis

08/01383 Energy crops in Ireland: quantifying the potential life-cycle greenhouse gas reductions of energy-crop electricity

Styles, D. and Jones, M. B. *Biomass and Bioenergy*, 2007, 31, (11–12), 759–772.

This study uses life-cycle assessment to compare greenhouse gas (GHG) emissions from dominant agricultural land uses, and peat and coal electricity generation, with fuel-chains for *Miscanthus* and short-rotation-coppice willow (SRCW) electricity. A simple scenario was used as an example, where 30% of peat and 10% of coal electricity generation was substituted with co-fired *Miscanthus* and SRCW, respectively. *Miscanthus* and SRCW cultivation were assumed to replace sugar-beet, dairy, beef-cattle and sheep systems. GHG emissions of 1938 and 1346 kg CO$_2$ eq. ha^{-1} a^{-1} for *Miscanthus* and SRCW cultivation compared with between 3494 CO$_2$ eq. ha^{-1} a^{-1} for sugar-beet cultivation and 12,068 CO$_2$ eq. ha^{-} a^{-1} for dairy systems. *Miscanthus* and SRCW fuel chains emitted 0.131 and 0.132 kg CO$_2$ eq. kWh^{-1} electricity exported, respectively, compared with 1.150 and 0.990 kg CO$_2$ eq. kWh^{-1} electricity exported for peat and coal fuel chains. 1.48 Mt CO$_2$ eq. a^{-1} was saved from electricity production, and 0.42 Mt CO$_2$ eq. a^{-1} was saved from displaced agriculture and soil C-sequestration. The total reduction of 1.9 Mt CO$_2$ eq. a^{-1} represents 2.8% of Ireland's 2004 GHG emissions, but was calculated to require just 1.7% of agricultural land area and displace just 1.2% of the dairy herd (based on conservative *Miscanthus* and SRCW combustible-yield estimates of 11.7 and 8.81 t ha^{-1} a^{-1} dry matter, respectively). A 50% increase in cultivation emissions would still result in electricity being produced with an emission burden over 80% lower than peat and coal electricity. Lower yield assumptions had little impact on total GHG reductions for the scenario, but required substantially greater areas of land. It was concluded that energy-crop utilization would be an efficient GHG reduction strategy for Ireland.

08/01384 Exergy losses during recycling and the resource efficiency of product systems

Castro, M. B. G. *et al. Resources, Conservation and Recycling*, 2007, 52, (2), 219–233.

Recycling materials have always some degree of contamination. The presence of contaminations in the recycling streams causes a shift in the original composition of the materials to recycle. As a consequence, their quality may decrease with each recycling step. Additionally, lower quality resources are produced from resource streams that had initially a higher quality. These quality losses cannot be measured by mass balances, as the quality degradation cannot be translated by mass measures alone. To account all losses caused by recycling contaminations, all downstream recycling processes required to bring the materials back to the resource cycles must be included. This article describes a method to calculate the exergy content and exergy losses of metal solutions during recovery and recycling. The losses attributed to recycling, namely the material losses, the contamination losses with other metals, and the consequent need for dilution can be used as indicators of the quality loss of materials and of the efficiency of resource use in product systems. Therefore, exergy is proposed here as a measure of the efficiency of resources use.

08/01385 Life cycle study of coal-based dimethyl ether as vehicle fuel for urban bus in China

Zhang, L. and Huang, Z. *Energy*, 2007, 32, (10), 1896–1904.

Using life cycle assessment (LCA) methodology, a life cycle model of coal-based dimethyl ether (CBDME) as a vehicle fuel is established for China. Its life cycle is followed from well to wheel and is divided into three phases. These phases are feedstock extraction, fuel production and fuel consumption in vehicle. The primary energy consumption (PEC) and global warming potential of CBDME pathway are analysed and compared with coal-based diesel (CBD) as a latent rival to replace conventional petroleum-based diesel (CPBD). This study demonstrates that the LCA methodology is very suitable and effective for the choice of vehicle fuels. One result is that the greenhouse gases (GHGs) emission of coal-based vehicle fuel pathways is usually concentrated on fuel production stage. The percentages of CBDME and CBD pathways both exceed 60%. The application of carbon capture and storage (CCS) is helpful for coal-based vehicle fuel pathways to improve their global warming effect dramatically. Compared with CBD pathway, CBDME pathway consumes less PEC and emits less GHGs emission as well. Even though the CCS and CH_4-fired generation are used, the advantages of CBDME are still kept. For saving petroleum energy and reducing global warming effect, CBDME has greater potential than CBD to substitute CPBD under current fuel synthesis technologies. If the hurdles such as the maturity of engine and vehicle technologies, corresponding regulations and standards and infrastructures are reliably solved, CBDME will have better prospect in China.

08/01386 Life-cycle flow of mercury and recycling scenario of fluorescent lamps in Japan

Asari, M. *et al. Science of the Total Environment*, 2008, 393, (1), 1–10.

We summarized the mercury flow of mercury-containing products from their manufacture to their disposal in Japan and discussed the current management of mercury-containing hazardous household waste (HHW). The mercury flow originating from these products was estimated to be about 10–20 tonnes annually, about 5 tonnes of which was attributable to fluorescent lamps, the major mercury-containing product in Japan. The recent rapid increase in digital home electronics with liquid crystal displays (e.g. televisions, personal computers, mobile phones, and digital cameras) has led to a marked increase in the production of backlights, which are also fluorescent and contain mercury. Most of the annual flow was disposed of as waste, with only 0.6 tonnes Hg recovered. The mercury flow for end-of-life fluorescent lamps (excluding backlights) was analysed under three scenarios for Kyoto, Japan for 2003: the present condition scenario, the improved recycling scenario, and the complete recycling scenario. Under the present condition scenario, mercury flow was calculated to be 34 kg Hg for incineration, 21 kg Hg for landfill, and only 4 kg Hg for recycling. The complete recycling scenario shows a simple flow, with all mercury recycled. Under this scenario for Kyoto, the authors calculated that a cyclic system having 47 kg of mercury (3.5 tonnes Hg in Japan) could be established if all fluorescent lamps (excluding those stored in residences) were collected and recycled. Mercury is a HHW priority chemical, and its use needs to be limited and a closed-loop system established. There are currently no regulations to achieve this, and the management of most HHWs is left to local governments. Therefore, products are disposed of in landfills or incinerated, except for some that are voluntarily collected and recycled. In order to recycle all of the waste fluorescent lamps, a complete recycling system must have a high rate of public participation in collection. Also a closed-loop system of mercury recovery and reuse is needed in which all stakeholders participate. Furthermore, it is important to share information and policies regarding fluorescent lamp recycling and related technologies with other countries, especially those in other countries, where fluorescent lamps are becoming more popular because of their high energy efficiency and long life. Also, it is important to develop mercury free and energy efficient lamps including LEDs (light emitting diodes).

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Supplies, policy, economics, forecasts

08/01387 Administrative, institutional and legislative issues on agricultural waste exploitation in Turkey

Kaya, D. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 417–436.

In this study, the influence of non-technical issues on the exploitation of agricultural waste in Turkey was investigated in accordance with the work program requirements for the project entitled 'Exploitation of Agricultural Waste in Turkey' under the EU Life Third Countries Program. The study has been organized and presented according to the following four phases: (i) study of existing Turkish legislation and the administrative and institutional framework, (ii) review and analysis of the EU policy and legislation relevant to agricultural waste, including identification of potential market instruments, (iii) identification of barriers to the promotion of agricultural waste exploitation in Turkey, and (iv) Identification of gaps and formulation of recommendations. An ultimate objective of this study is to transfer the European experience and practices relative to the overall framework of managing agricultural waste.

08/01388 An enterprise energy-information system

Swords, B. *et al. Applied Energy*, 2008, 85, (1), 61–69.

This paper outlines the background, development, and assessment of a prototype enterprise energy information system (EEIS) that supports strategic energy-management by providing comprehensive energy monitoring and targeting, integrating with energy modelling software and enterprise business databases, and supporting measurement and verification. The EEIS prototype system was developed and assessed in an industrial site and a third-level education institution with colleges throughout Dublin. The industrial site provided the opportunity for the EEIS to meet the requirements of a large energy intensive site, and to integrate with energy modelling software. The higher education establishment accommodated the development of a networked energy-information system.

08/01389 Assessment of new and renewable energy resources potential and identification of barriers to their significant utilization in Pakistan

Sahir, M. H. and Qureshi, A. H. *Renewable and Sustainable Energy Review*, 2008, 12, (1), 290–298.

The paper presents a review of the assessed potential of the renewable resources and practical limitations to their significant use in the context of present scenarios and future projections of the national energy mix for Pakistan. Solar, wind, biomass and micro hydel resources are likely to play an important role in future; however these should be seen as supplementary resources and not as alternatives. IEP approach and consistent policy instruments are needed for sustainable development of RETs.

08/01390 Bioenergy expansion in the EU: cost-effective climate change mitigation, employment creation and reduced dependency on imported fuels

Berndes, G. and Hansson, J. *Energy Policy*, 2007, 35, (12), 5965–5979.

Presently, the European Union is promoting bioenergy. The aim of this paper is to study the prospects for using domestic biomass resources in Europe and specifically to investigate whether different policy objectives underlying the promotion of bioenergy (cost-effective climate change mitigation, employment creation and reduced dependency on imported fuels) agree on which bioenergy options that should be used. The authors model bioenergy use from a cost-effectiveness perspective with a linear regionalized energy- and transport-system model and perform supplementary analysis. It is found that the different policy objectives do not agree on the order of priority among bioenergy options. Maximizing climate benefits cost-effectively is in conflict with maximizing employment creation. The former perspective proposes the use of lignocellulosic biomass in the stationary sector, while the latter requires biofuels for transport based on traditional agricultural crops. Further, from a security-of-supply perspective, the appeal of a given bioenergy option depends on how oil and gas import dependencies are weighed relative to each other. Consequently, there are tradeoffs that need to be addressed by policymakers promoting the use of bioenergy. Also, the importance of bioenergy in relation to employment creation and fuel import dependency reduction needs to be further addressed.

08/01391 Disputes and their resolution under the Mining Code 2002 of the Democratic Republic of Congo

André-Dumont, H. *Journal of Energy and Natural Resources Law*, 2007, 25, (4), 351–374.

The new Mining Code of the Democratic of Congo (DRC), adopted in 2002, and its ancillary Mining Regulation, adopted in 2003, thoroughly modified and reshaped the legal system applicable to mining rights in the DRC, including ‘mining’ disputes and their resolution. In particular, the Mining Code 2002 organizes three ways to resolve them, namely administrative recourse, judicial recourse and arbitral recourse. The recourse system organized by the Mining Code 2002 generally lacks cohesion and consistency and the issues listed above could create serious legal uncertainty. It is debatable whether judicial or arbitral recourses are the most appropriate to question an administrative act where the most appropriate solution would be to obtain its annulment, when in fact the judicial recourse or the arbitral recourse cannot achieve this (although they can achieve solutions leading to similar effects, for instance by ordering the non-application of the decision). Judicial recourse, however, offers an additional jurisdictional appeal level, while international arbitration affords a certain safeguard. Domestic arbitration appears to be the less suitable recourse and should not be recommended. It is advisable, at any rate, *de lege ferenda*, to provide a certain number of improvements to address possible inconsistencies and inaccuracies, in order to render the recourse system more coherent and more efficient and reassure investors in that respect.

08/01392 Economic and CO_2 mitigation impacts of promoting biomass heating systems: an input–output study for Vorarlberg, Austria

Madlener, R. and Koller, M. *Energy Policy*, 2007, 35, (12), 6021–6035.

This paper reports on an empirical investigation about the economic and CO_2 mitigation impacts of bioenergy promotion in the Austrian federal province of Vorarlberg. The authors study domestic value-added, employment, and fiscal effects by means of a static input–output analysis. The bioenergy systems analysed comprise biomass district heating, pellet heating, and automated wood chip heating systems, as well as logwood stoves and boilers, ceramic stoves, and buffer storage systems. The results indicate that gross economic effects are significant, regarding both investment and operation of the systems, and that the negative economic effects caused by the displacement of conventional decentralized heating systems might be in the order of 20–40%. Finally, CO_2 mitigation effects are substantial, contributing already in 2004 around 35% of the 2010 CO_2 mitigation target of the Land Vorarlberg for all renewable energy sources.

08/01393 Effects of stochastic energy prices on long-term energy-economic scenarios

Krey, V. *et al. Energy*, 2007, 32, (12), 2340–2349.

In view of the currently observed energy prices, recent price scenarios, which have been very moderate until 2004, also tend to favour high future energy prices. Having a large impact on energy-economic scenarios, uncertain energy prices are incorporated into an energy systems model by including a stochastic risk function. Energy systems models are frequently used to aid scenario analysis in energy-related studies. The impact of uncertain energy prices on the supply structures and the interaction with measures in the demand sectors is the focus of the present paper. For the illustration of the methodological approach, scenarios for four EU countries are presented. Including the stochastic risk function, elements of high energy price scenarios can be found in scenarios with a moderate future development of energy prices. In contrast to scenarios with stochastic investment costs for a limited number of technologies, the inclusion of stochastic energy prices directly affects all parts of the energy system. Robust elements of hedging strategies include increasing utilization of domestic energy carriers, the use of CHP and district heat and the application of additional energy-saving measures in the end-use sectors. Region-specific technology portfolios, i.e. different hedging options, can cause growing energy exchange between the regions in comparison with the deterministic case.

08/01394 Empirical analysis of optimal strategic petroleum reserve in China

Wei, Y.-M. *et al. Energy Economics*, 2008, 30, (2), 290–302.

The Chinese government began to prepare for the establishment of strategic petroleum reserve in March 2004. Therefore, answering the question of what level of strategic petroleum reserve would be suitable for China’s future economic development becomes essential. Using a decision tree model based on a cost function, this paper quantifies China’s optimal strategic petroleum reserve for the period 2005–2020. This approach provides a methodology reference for further quantified discussion on China’s SPR. The results show that: for economic development and security of the energy supply, the strategic petroleum reserve should be the equivalent of 30–60 days of net oil import for an optimal solution, when the oil price is $ 50/bbl; with a reserve of an equivalent of 60–90 days of net oil import to have an optimal solution when oil price is $ 20–35/bbl.

08/01395 Energy consumption and GDP in Turkey: is there a co-integration relationship?

Lise, W. and Van Montfort, K. *Energy Economics*, 2007, 29, (6), 1166–1178.

Energy consumption and GDP are expected to grow by 5.9% and 7% annually until 2025 in Turkey. This paper tries to unfold the linkage between energy consumption and GDP by undertaking a co-integration analysis for Turkey with annual data over the period 1970–2003. The analysis shows that energy consumption and GDP are co-integrated. This means that there is a (possibly bi-directional) causality relationship between the two. It is established that there is a unidirectional causality running from GDP to energy consumption indicating that energy saving would not harm economic growth in Turkey. In addition, it is found that energy consumption keeps on growing as long as the economy grows in Turkey.

08/01396 Energy, environment and development in Bhutan

Uddin, S. N. *et al. Renewable and Sustainable Energy Reviews*, 2007, 11, (9), 2083–2103.

Bhutan’s energy and environmental situation and approaches to development are reviewed and analysed in this paper. Conservation of natural resources and human happiness have been placed as central strategic policy themes and have been given high priority in the national development plans of Bhutan. Bhutan’s unique approach to development via ‘gross national happiness’ or ‘the middle path’ of development is being facilitated by the Royal Government of Bhutan as a tool to balance poverty alleviation, environmental conservation and development. However, challenges exist due to the constraints of resources, good governance, legal frameworks, and human capacity. This paper reviews selected sustainable energy projects (e.g. energy from renewables or energy conservation) in Bhutan and finds that in fact, Bhutan’s renewable energy resources (e.g. water and forests) which have proved to be indispensable for development are vulnerable due to the adverse impacts of climate change and environmental degradation. Appropriate measures in order to reduce potential environmental degradation and mitigate climate change impacts have been acknowledged globally and these have potential for application in Bhutan. For example, implementation of sustainable energy projects under the clean development mechanism of the Kyoto Protocol could offer an opportunity for mitigating climate change impacts and also contributing to sustainable development.

08/01397 Former Soviet Union oil production and GDP decline: Granger causality and the multi-cycle Hubbert curve

Reynolds, D. B. and Kolodziej, M. *Energy Economics*, 2008, 30, (2), 271–289.

This paper discusses the transition of the Former Soviet Union (FSU) within the context of a 1987–1996 Soviet and FSU oil production decline. The conventional explanation of the break-up is that economic inefficiencies and the Cold War defense build-up caused it. Another possible explanation, one that is examined at length here, is that declining oil production was a contributing factor. The econometric analysis suggests that the fall in Soviet and former Soviet GDP in the 1980s and 1990s did not Granger cause the decline in oil production, but the decline in oil production did Granger cause the fall in GDP. Coal and natural gas to GDP relationships show alternative Granger causalities that the authors would expect to see with oil, but do not. A multi-cycle Hubbert trend that may be used to forecast future FSU oil production is also shown.

08/01398 Impacts of policy means for increased use of forest-based bioenergy in Norway – a spatial partial equilibrium analysis

Trømborg, E. *et al. Energy Policy*, 2007, 35, (12), 5980–5990.

Like the European Union (EU), Norway has defined quite ambitious targets regarding increased use of bioenergy. However, the bioenergy market develops relatively slowly, and stronger policies seem necessary to reach the targets. This study analyses how different policy means, high on the agenda in the Norwegian energy debate, may affect the use of forest-based bioenergy in Norway. The means studied are (i) subsidies reducing investment costs of district heating installations, (ii) deposit grant for replacement of oil burners with burners based on bioenergy (iii) feed-in supporting energy production in district heating based on bioenergy. The study is based on a regionalized partial equilibrium model covering forestry, forest industries and the bioenergy sector. The advantage of this methodology is that it allows for assessments of the economic potential of bioenergy under different policy alternatives, taking into account the competition for raw materials from the forest industries, regional differences regarding heat demand and wood fibre supply, as well as important spatial aspects connected to inter-regional transport and trade of wood. The results of the study give medium-term projections for bioenergy use in Norway under different bioenergy policy regimes. Some investments in bioburners in central heating systems and new district heating based on bioenergy are profitable at the current energy prices, but policy incentives in terms of grants, subsidies or feed-in systems make it possible to overcome inertia in investments decisions and provide substantial increase in the supply of bioenergy. The results show that the analysed policy means are effective at the current energy price levels and have a significant impact on bioenergy production. While some results are specific to Norway, other results and the methodology used are of more general value also to other European countries.

08/01399 Incentive policies for promoting wind power production in Brazil: scenarios for the alternative energy sources incentive program (PROINFA) under the new Brazilian electric power sector regulation

Dutra, R. M. and Szklo, A. S. *Renewable Energy*, 2008, 33, (1), 65–76.

The alternative energy sources incentive program (PROINFA) was designed in 2002 to stimulate the electricity generation from three energy sources (wind, biomass and small-scale hydro) in Brazil. The Program was divided into two phases. The first one uses feed-in tariffs for promoting the development of 3300 MW. The second one that was originally based on feed-in tariffs was modified in 2003, in order to be based on biddings for renewables. These biddings are capped to limit their impact on the final electricity tariff. Due to this bound, the highest-cost power option promoted by PROINFA (wind power generation) might have development problems. Simulating different scenarios for the biddings, it was verified that the only way to reach the original goal set by PROINFA (10% of the annual electricity consumption provided by alternative sources up to 2020) and, simultaneously, not overcome the bidding bound is to promote biomass-fired power generation alone, during the Program's second phase. However, this action contradicts one of the targets of the program, which is to diversify the energy matrix. An alternative option could be biddings for renewables according to specific criteria (complementarities, industrial and technological development and cost), based not only on their cost-effectiveness.

08/01400 Spatial distribution of agricultural residue from rice for potential biofuel production in China

Elmore, A. J. *et al. Biomass and Bioenergy*, 2008, 32, (1), 22–27.

In China, agricultural residues (particularly from rice) are widely used for energy and other applications, albeit on a localized scale and often at poor rates of efficiency. If some portion of this biomass were to be reallocated and transported to central biomass energy facilities, an initial component of the design process would be to gain an understanding of the spatial distribution of biomass production. In this paper, a method is presented that utilizes China-wide data sets of net primary production from the moderate-resolution imaging spectrometer and detailed land cover maps produced from Landsat-enhanced thematic mapper plus data to calculate the spatial distribution of rice straw for the period 2000–2004. Through a comparison with census statistics, it is shown that remote measures of rice straw can reasonably predict census results at the provincial scale. Remote sensing results have the added benefits of being a quick and inexpensive solution for providing spatially detailed information. Therefore, these data can be used for applications such as the spatial optimization of energy production infrastructure. In an error analysis including climate and land use variables, it was found that data on sown rice area is the largest source of error. Therefore, the most important improvement to this method would be more accurate and more frequently updated maps of agricultural land use.

08/01401 Sustainable utilisation of forest biomass for energy – possibilities and problems: policy, legislation, certification, and recommendations and guidelines in the Nordic, Baltic, and other European countries

Stupak, I. *et al. Biomass and Bioenergy*, 2007, 31, (10), 666–684.

The substitution of biomass for fossil fuels in energy consumption is a measure to mitigate global warming, as well as having other advantages. Political action plans for increased use exist at both European and national levels. This paper briefly reviews the contents of recommendations, guidelines, and other synthesis publications on sustainable use of forest biomass for energy. Topics are listed and an overview of advantages, disadvantages, and trade-offs between them is given, from the viewpoint of society in general and the forestry and energy sectors in particular. For the Nordic and Baltic countries, the paper also identifies the extent to which wood for energy is included in forest legislation and forest certification standards under the Programme for the Endorsement of Forest Certification (PEFC) and the Forest Stewardship Council schemes. Energy and forest policies at EU and national levels, and European PEFC forest standards are analysed. With respect to energy policies, the utilization of wood for energy is generally supported in forest policies, but forest legislation is seldom used as a direct tool to encourage the utilization of wood for energy. Regulations sometimes restrict use for environmental reasons. Forest certification standards include indicators directly related to the utilization of wood for energy under several criteria, with most occurrences found under environmental criteria. Roles and problems in relation to policy, legislation, certification standards, recommendations and guidelines, and science are discussed.

08/01402 The municipal solid waste incineration sector in Europe: a study of harmonisation and its impact

Suder, G. *International Journal of Environment and Waste Management*, 2007, 1, (4), 391–405.

This article discusses how sustainable development and quality management meet a common target. Companies that excel in best available technology respond to expanding sets of expectation of the client and of the legislator. The paper analyses the link between governance, lobbying, and the emergence of economic and environmental feasibility of current quality management factors. In conclusion, the author argues that organizations function in dependence of how well quality improvement interacts with different competitive components such as cost. The constraint theory of Goldratt is therefore extended; this paper is hence first in literature to report an analysis of linkages between the political economy, public affairs management and its impact on harmonization in the sector of waste management.

08/01403 The US–India nuclear agreement: progress toward nuclear cooperation with India and a new paradigm in non-proliferation policy

Kraemer, J. R. and Aum, F. *International Journal of Nuclear Law*, 2007, 1, (4), 418–439.

The enactment of the Henry J. Hyde United States–India Peaceful Atomic Energy Cooperation Act on 18 December 2006 opened the door to a change in US nuclear export policy toward India. The new legislation could reverse three decades of US nuclear non-proliferation policy by facilitating India's exemption from the requirement of full-scope safeguards as a prerequisite for nuclear trade and cooperation. Notwithstanding the Hyde Act, however, major US nuclear exports to India remain unlawful until further implementing steps are taken. This article outlines the history of the estranged nuclear trade relations between the US and India and the motivations for reviving substantial civil nuclear cooperation. It then describes the parties' recent agreements and the changes to US law necessary to fulfill those agreements. Finally, the article discusses the provisions of the Hyde Act itself and the remaining principal obstacles to US–India nuclear trade.

08/01404 Variation in energy consumption in production of wheat–maize with varying altitudes in hilly regions of Himachal Pradesh, India

Mani, I. *et al. Energy*, 2007, 32, (12), 2336–2339.

Availability and consumption pattern of energy and constraints in its proper supply and management for crop production was studied in wheat–maize cropping system in selected hilly rural villages located at different altitudes of Himachal Pradesh in Western Himalayas. The information was collected from 90 farmers drawn from nine villages, three each from three selected altitudes using two-stage random sampling. The average values of energy consumption for wheat crop in low and high hills were, respectively, 41.68 and 110.8 MJ/ha and those for maize crop were, respectively, 43.43 and 81.33 MJ/ha. The productivity of wheat crop ranged from 1077 to 1840.9 kg/ha and for maize crop from 1108 to 1573 kg/ha, in low and high hills, respectively. The major constraints in the proper use of energy in crop production were the uncertain supply of different inputs due to difficult and undulating terrain, poor land holdings and non-availability of suitable technologies. The introduction of small powered equipment, precise use of seed and fertilizer and proper management of irrigation water were recommended for efficient energy use and better crop productivity.

08/01405 Welfare impacts of electricity generation sector reform in the Philippines

Toba, N. *Energy Policy*, 2007, 35, (12), 6145–6162.

This paper reports an empirical investigation into the welfare impacts of the introduction of private sector participation into the Philippines electricity generation sector, by liberalizing the market for independent power producers (IPPs) during the power crisis of 1990–1993. This study uses a social cost and benefit analysis. The main benefits came from IPPs, who contributed to resolving the crisis, and promoted economic and social development. Consumers and investors were net gainers, while the government lost and there was an air pollution cost. The paper concludes that the reform with private sector participation increased social welfare.

08/01406 Wood fuel supply, costs and home consumption in Lithuania

Mizaraite, D. *et al. Biomass and Bioenergy*, 2007, 31, (10), 739–746.

This paper examines the possibilities of increasing the use of wood from private forests in Lithuania for bioenergy purposes. Potential wood fuel supply and consumption were investigated using a literature review and analysis of statistical data. Costs of wood chips production were calculated applying economic simulation. The analysis showed that 0.6 Mm^3 (1.2 TWh) of firewood is produced and about 0.3 Mm^3 (0.6 TWh) of forest logging residues could be used annually for fuel in private forests. The available volume will increase in coming decades. In total, Lithuanian households had increased wood fuel consumption by five times during 10 years and exceeded 2.3 Mm^3 (4.6 TWh) in 2003. Firewood production for home consumption is one of the most important forest owners' objectives. The cost of forest chips varied from 19 to 36 $€\,\mathrm{m}^{-3}$ in pre-commercial thinnings and from 20 to 28 $€\,\mathrm{m}^{-3}$ in final thinnings. The lack of specific policies supporting the use of natural resources is causing a lack of incentive to increase the use of local fuels.

Energy conservation

08/01407 A climate-change policy induced shift from innovations in carbon-energy production to carbon-energy savings

Gerlagh, R. *Energy Economics*, 2008, 30, (2), 425–448.

In this paper, the authors develop an endogenous growth model with capital, labour and carbon-energy as production factors and three technology variables that measure accumulated innovations for carbon-energy production, carbon-energy savings, and neutral growth. All markets are complete and perfect, except for research, for which it is assumed that the marginal social benefits exceed the marginal private benefits by factor four. The model constants are calibrated so that the model reproduces the relevant global trends over the 1970–2000 period. The model contains a simple climate module, and is used to assess the impact of induced technological change (ITC) for a policy that aims at a maximum level of atmospheric CO_2 concentration (450 ppmv). ITC is shown to reduce the required carbon tax by more than a factor 2, and to reduce costs of such a policy by half. When aggregate R&D expenditures is not constrained to benchmark levels, costs are further reduced. Numerical simulations show that knowledge accumulation shifts from energy production to energy saving technology. The authors discuss reasons for differences between the results and earlier results reported in the literature.

08/01408 A review of energy conservation initiatives by the Government of India

Nandi, P. and Basu, S. *Renewable and Sustainable Energy Review*, 2008, 12, (2), 518–530.

Energy conservation is the need of the hour. The first oil shock of 1973 shook up the industrialized nations of the world and awakened them from the sleepy complacency of never-ending oil flow. It made them face the stark reality of the uncertainty in oil supply restoration and the fragility of the trade in oil. This was the time when many countries realized the urgent need for energy conservation. Notably, the wave of energy conservation had struck the Indian intelligentia 3 years earlier when a Fuel Policy Committee was set up by the Government of India in 1970, which finally bore fruits three decades hence in the form of enactment of the much awaited Energy Conservation Act, 2001 by the Government of India. This act made provisions for setting up of the Bureau of Energy Efficiency, a body corporate incorporated under the Act, for supervising and monitoring the efforts on energy conservation in India. In this article the stages in the historical development of energy conservation in India, the government initiatives taken in this regard and the reasons for the limited success in implementation of conservation policies in the past have been discussed.

08/01409 Air flow rates and energy saving potential in schools with demand-controlled displacement ventilation

Wachenfeldt, B. J. *et al. Energy and Buildings*, 2007, 39, (10), 1073–1079.

Demand control is particularly energy efficient and reliable when combined with displacement ventilation (DCDV). In order to investigate how much DCDV in practice reduce the ventilation air volumes and the energy demand, two Norwegian schools with CO_2-sensor based demand controlled displacement ventilation (DCDV-CO_2), Jaer School and Mediå School, are analysed and compared with traditional constant air volume mixing ventilation. During daytime operation with normal school activity, DCDV-CO_2 reduces the ventilation air volume by 65–75% in both schools compared to CAV. For Mediå School, both the airflow rates and the energy performance were analysed through measurements and use of a detailed, calibrated simulation model. The analysis period was 11–17 November, 2002. It was found that during this week, DCDV-CO_2 daytime operation weekdays reduce the total heating energy demand by 21%, the amount of unrecovered heat in the exhaust ventilation air by 54%, and the average airflow rate by 50%. Presuming constant fan efficiency it was also found that DCDV-CO_2 daytime operation weekdays reduce the fan energy consumption by 87% the analysed week.

08/01410 Application of genetic algorithm to the optimal-chilled water supply temperature calculation of air-conditioning systems for saving energy

Chang, Y.-C. *International Journal of Energy Research*, 2007, 31, (8), 796–810.

Chilled water supply temperatures of chillers indicate their load distributions due to the chilled water return temperatures of all chillers being the same in a decoupled air-conditioning system. This study employs a genetic algorithm (GA) to find out the chilled water supply temperatures of chillers for solving optimal chiller loading (OCL) problems. GA overcomes the flaw that the Lagrangian method is not adaptable for solving OCL as the power consumption models or the kW-partial load ratio curves include non-convex functions. This study uses the chilled water supply temperature as the variable to binary code chromosomes, and execute reproduction, crossover and mutation operation. After analysis and comparison of the case study, it has been concluded that this method not only solves the problem of Lagrangian method, but also produces results with high accuracy within a rapid timeframe. It can be perfectly applied to the operation of air-conditioning systems.

08/01411 Applying uncertainty considerations to energy conservation equations

Macdonald, I. A. and Clarke, J. A. *Energy and Buildings*, 2007, 39, (9), 1019–1026.

When applying computer simulation tools in practice uncertainties abound, for example in material properties and boundary conditions. To facilitate the quantification of the effects of uncertainties, the differential, factorial and Monte Carlo methods have been implemented within a simulation tool, ESP-r. These methods require multiple simulations to extract statistical measures of model uncertainty. An alternative approach is to embed uncertainty considerations within the simulation tool's algorithms. The principle advantages of this approach are that the uncertainty is quantified at all times and therefore requires only a single simulation. Coupled with this, it is possible to take control action based on the prevailing effects of uncertainties. This paper details the mathematical techniques required to integrate uncertainty considerations within the energy conservation equations when applied to the simulation of buildings. A comparison is made between the use of this novel approach and traditional mechanisms of assessing uncertainty.

08/01412 Changes in year-round air temperature and annual energy consumption in office building areas by urban heat-island countermeasures and energy-saving measures

Ihara, T. *et al. Applied Energy*, 2008, 85, (1), 12–25.

This paper describes the effects of the installation of various countermeasures against urban heat-island (UHI) and energy-saving measures on UHI and global warming. A UHI and energy-consumption simulation model was developed by combining the one-dimensional meteorological canopy and building energy-use models; further, the proposed model was expanded to evaluate the year-round air temperature and annual energy consumption. The simulation results showed that the humidification and albedo increase at building-wall surfaces reduced the total number of hours for which the air temperature was more than 30 °C during the daytime by more than

60 (h) per year. The UHI countermeasures reduced the annual energy-consumption despite causing a small increase during the winter period. However, they may result in certain unfavourable conditions for pedestrians. Energy-saving measures, on the other hand, reduce the total number of hours for which the air temperature is more than 30 °C by only a few hours per year. Thus, the authors demonstrate the effectiveness of the UHI countermeasures and measures against global warming by extending the calculation period from summer to an entire year.

08/01413 Comparison of user performance when applying system identification for assessment of the energy performance of building components

Androutsopoulos, A. *et al. Building and Environment*, 2008, 43, (2), 189–196.

The application of system identification techniques to the energy performance assessment of buildings and building components requires a high level of knowledge of physical and mathematical processes. This factor, combined with the quality of the data, the description of the monitoring procedure and test environment, together with the experience of the user of the analysis software itself, can produce varying results from different users when applying different models and software packages. Past international system identification competitions (1994 and 1996) demonstrated the spread in results that can be expected regarding the application of different models and techniques to the same benchmark data. The PASLINK EEIG has attempted to consolidate and strengthen knowledge and expertise of system identification techniques within the grouping and also ensure that data analysis meets minimum quality levels. This paper compares the spread in results obtained during the previous competitions to that obtained during the workshops carried out by the PASLINK EEIG following 10 years of networking activities in the field. The objective is to identify the extent to which the networking activities have strengthened the position of the individual teams working in the field and to identify the areas where quality assurance is met and, furthermore, where further improvements can be made. A direct comparison of the quality of results obtained during data analysis from the previous decade is made with recent results after a significant period of collaboration and networking activities.

08/01414 Energy code for office buildings in Israel

Shaviv, E. *et al. Renewable Energy*, 2008, 33, (1), 99–104.

A new energy code for office buildings in Israel, currently under development, is presented. This code is based on a prescriptive approach, which can be easily applied as a tool for the design of office buildings through all the design stages including the early ones. The prescriptive approach suggested is based on the results obtained from an energetic–economic optimization model that provides a recommended and preferred prescription for office building under given constraints. A sensitivity analysis of the optimized solution follows. The sensitivity analysis permits modifications of the recommended prescription allowing for the creation of a wide range of design alternatives and in addition to figure out what are the design variables with the highest impact on the building energy consumption and cost. The way of using the prescriptions as a building code is explained as well as the method to determine the energetic rank of the chosen solution.

08/01415 Energy use efficiency in U.S. manufacturing: a nonparametric analysis

Mukherjee, K. *Energy Economics*, 2008, 30, (1), 76–96.

This study approaches the measurement of energy use efficiency in the US manufacturing sector from a production theoretic perspective. The method of Data Envelopment Analysis is utilized to analyse the energy efficiency for the aggregate manufacturing sector as well as for the six highest energy consuming two-digit sectors for the period 1970–2001, and several alternative models are proposed. The new measures of energy efficiency suggested in this study do provide some additional insights and could be helpful if used alongside the traditional measure of energy efficiency based on energy intensity.

08/01416 Fabric-drying process in domestic dryers

Yadav, V. and Moon, C. G. *Applied Energy*, 2008, 85, (2–3), 143–158.

A theoretical analysis of the drying process occurring inside the household electric tumbler clothes-dryer is performed to determine various thermo-physical parameters affecting the energy consumption and for the development of a simulation model. Experiments are conducted on a test set-up, based on a compact tumble-dryer, to measure the values of the parameters necessary for evaluating the performance. Widely accepted economy standards are considered for comparison of simulation and experimental results. The simulation results are in reasonable agreement with experimental data. An empirical correlation for the specific moisture-extraction rate is developed to translate energy-consumption information from one standard to the other.

08/01417 Retrofit of ammonia plant for improving energy efficiency

Panjeshahi, M. H. *et al. Energy*, 2008, 33, (1), 46–64.

The aim of this work is to perform a retrofit study of an ammonia plant, in purpose of improving energy efficiency. As a common practice, one can divide an ammonia plant into two parts: the hot-end and the cold-end. In the hot section, two different options are investigated that both lead to a threshold condition and achieve maximum energy saving. The first option covers only process-to-process energy integration, while the second option considers some modification in the convection section of the primary reformer through a new arrangement of the heating coils. Thus, a considerable reduction in cooling water, HP steam and fuel gas consumption is achieved. In the cold section, retrofit study is dominated by reducing the amount of shaft work or power consumption in the refrigeration system. Application of the combined pinch and exergy analysis revealed that part of the shaft work, which was originally being used, was inefficient and could have been avoided in a well-integrated design. Therefore, by proposing optimum refrigeration levels, reasonable saving (15%) in power consumption was observed without the need for new investment.

08/01418 Roof pond cooling of buildings in hot arid climates

Kharrufa, S. N. and Adil, Y. *Building and Environment*, 2008, 43, (1), 82–89.

The weather in Baghdad, Iraq is hot dry in the summer while water is plentiful and cheap. These are conditions which encourage the use of evaporative cooling. A building with one space in it was used to test the effect of a roof pond which was ventilated mechanically for summer cooling. Thermal measurements were taken for the room in normal conditions without a pond, with a lone pond and no mechanical ventilation, and then finally with mechanically forced ventilation. The results showed a marked improvement in the space temperature with a significant reduction during the peak time outside temperatures at 3 o'clock reaching 6.0 °C between the room without the pond and with a ventilated one and 6.5° at 18:00 during peak inside temperatures. The study also showed that improvements would be better in real-life conditions where exterior wall area is less than the test room.

08/01419 The interorganizational innovation processes of sustainable building: a Dutch case of joint building innovation in sustainability

Bossink, B. A. G. *Building and Environment*, 2007, 42, (12), 4086–4092.

This article's subject is the cooperation process between organizations that develop and implement innovations in sustainable building. Its main research question is how governmental and commercial organizations organize and structure their joint activities to develop innovations in sustainability. In the search for answers to this question the cooperative activities of innovating organizations are modelled as an interorganizational innovation process. The case study research method is used to investigate the development of interorganizational innovation patterns in sustainability in seven house-building projects in the Dutch residential building sector. The empirical research findings are discussed by means of a comparison with the theoretical framework that includes five complementary stage models of interorganizational innovation processes. The main conclusions of the research are that (1) governmental and commercial organizations that successfully innovate in sustainability go through eight consecutive stages of interorganizational innovation, and (2) perform 22 interaction patterns that are part of these stages.

08/01420 Trigeneration primary energy saving evaluation for energy planning and policy development

Chicco, G. and Mancarella, P. *Energy Policy*, 2007, 35, (12), 6132–6144.

Trigeneration or combined heat, cooling and power (CHCP) is becoming an increasingly important energy option, particularly on a small-scale basis (below 1 MW$_e$), with several alternatives nowadays available for the cooling power production and the coupling to cogeneration systems. This paper deals with the introduction of a suitable framework for assessing the energy saving performance of trigeneration alternatives, orientated towards energy planning studies and the development of regulatory policies. In particular, a new generalized performance indicator – the trigeneration primary energy saving (TPES) – is introduced and discussed, with the aim of effectively evaluating the primary energy savings from different CHCP alternatives. The potential of the TPES indicator is illustrated through specific analyses run over different combinations of trigeneration equipment, providing numerical examples based on time-domain simulations to illustrate the dependence of the energy saving characteristics on the CHCP system configurations and equipment, as well as on the loading levels. In addition, the key aspect of adequately establishing the reference efficiencies for the conventional separate production of electrical, thermal and cooling power is addressed in detail. This aspect affects both equipment selection and potential profitability of the considered solutions under the outlook of receiving financial incentives.

08/01421 The greenhouse gas and energy impacts of using wood instead of alternatives in residential construction in the United States

Upton, B. *et al. Biomass and Bioenergy*, 2008, 32, (1), 1–10.
Data developed by the Consortium for Research on Renewable Industrial Materials were used to estimate savings of greenhouse gas emissions and energy consumption associated with use of wood-based building materials in residential construction in the United States. Results indicate that houses with wood-based wall systems require 15–16% less total energy for non-heating/cooling purposes than thermally comparable houses employing alternative steel- or concrete-based building systems. Results for non-renewable energy consumption are essentially the same as those for total energy, reflecting the fact that most of the displaced energy is in fossil fuels. Over a 100-year period, net greenhouse gas emissions associated with wood-based houses are 20–50% lower than emissions associated with thermally comparable houses employing steel- or concrete-based building systems. Assuming 1.5 million single-family housing starts per year, the difference between wood and non-wood building systems represents about 9.6 Mt of CO_2 equivalents per year. The corresponding energy benefit associated with wood-based building materials is approximately 132 PJ year^{-1}. These estimates represent about 22% of embodied energy and 27% of embodied greenhouse gas emissions in the residential sector of the US economy. The results of the analysis are very sensitive to assumptions and uncertainties regarding the fate of forestland that is taken out of wood production due to reduced demand for wood, the continued production of co-products where demand for wood products is reduced, and the rate at which carbon accumulates in forests.

17 ENERGY CONVERSION AND RECYCLING

08/01422 An investigation of the existing situation and trends in building energy efficiency management in China

Liang, J. *et al. Energy and Buildings*, 2007, 39, (10), 1098–1106.
According to the Chinese State Council's 'Building Energy Efficiency Management Ordinance', a large-scale investigation of energy efficiency in buildings in contemporary China has been carried out in 22 provincial capitals and major cities in China. The aim of this project is to provide reliable information for drawing up the 'Decision on reinforcing building energy efficiency' by the Ministry of Construction of China. The surveyed organizations include government departments, research institutions, property developers, design institutions, construction companies, construction consultancy services companies, facility management departments, financial institutions and those which relate to the business of building energy efficiency. In addition, representatives of the media and residents were also involved. A detailed analysis of the results of the investigation concerning aspects of the current situation and trends in building energy consumption, energy efficiency strategy and the implementation of energy efficiency measures has been conducted. The investigation supplies essential information to formulate the market entrance policy for new buildings and the refurbishment policy for existing buildings to encourage the development of energy efficient technology.

08/01423 Balancing energy and environment: the effect and perspective of management instruments in China

Fang, Y. and Zeng, Y. *Energy*, 2007, 32, (12), 2247–2261.
The rapid growth of Chinese economy has tremendously stimulated the expansion of energy consumption. The structure of energy consumption in China is featured with the coal domination. Air pollution is becoming increasingly severe. As a result, the authors are confronted with the extremely arduous task to balance energy consumption and environmental protection. In order to coordinate the relationship between energy consumption and environmental protection in a strategic way, this paper analyses comprehensively the instruments, effects and perspectives of energy-related environmental management. Meanwhile, this paper illustrates the barriers and challenges facing the energy and energy-related environmental management in China, and suggests a priority strategy of management instrument, mainly composed of energy-saving, optimization of energy structure, promulgation of environmental standards, advance in environmental technologies, internalization of environmental costs, establishment of a public benefit fund and adoption of a renewable portfolio system.

08/01424 Biotechnological valorisation of raw glycerol discharged after bio-diesel (fatty acid methyl esters) manufacturing process: production of 1,3-propanediol, citric acid and single cell oil

Papanikolaou, S. *et al. Biomass and Bioenergy*, 2008, 32, (1), 60–71.
Raw glycerol, a byproduct from the bio-diesel production process, is used as carbon substrate in several biotechnological applications. Using *Clostridium butyricum* F2b, 47.1 g L^{-1} of 1,3-propanediol was produced in batch anaerobic cultures while substrate uptake rate (r_S, expressed in g L^{-1} h^{-1}) increased with increase in glycerol concentration in the medium. In continuous cultures, microbial behaviour was studied in transitory states after addition of 1,3-propanediol in the chemostat vessel. Microbial growth was not affected by the high 1,3-propanediol (which was added in the chemostat vessel) concentration, while butyric and acetic acids concentrations were increased. In a two-stage continuous culture, 43.5 g L^{-1} of 1,3-propanediol was produced with a total volumetric productivity of 1.33 g L^{-1} h^{-1}. *Yarrowia lipolytica* ACA-DC 50109 was grown in nitrogen-limited aerobic cultures on raw glycerol and it exhibited remarkable biomass production even at high glycerol concentration media, while r_S decreased with increase in glycerol concentration. Citric acid was produced after nitrogen depletion in the medium, with the highest quantity of 62.5 g L^{-1}, and yield on glycerol consumed was 0.56 g g^{-1}. Fatty acid analysis of total cellular lipids showed that glycerol concentration increase in the growth medium somehow increased the cellular unsaturated fatty acids content of lipids. *Mortierella isabellina* ATHUM 2935 exhibited satisfactory growth in nitrogen-limited aerobic cultures with raw glycerol used as sole substrate. When high initial glycerol quantities were employed (e.g. 100 g L^{-1}), 4.4 g L^{-1} of lipid were accumulated corresponding to around 51% (wt/wt) of lipid in dry weight. r_S constantly decreased with increase in glycerol concentration in the medium, and in all cases notable glycerol quantities remained unconsumed in the medium.

08/01425 Effects of solid–liquid separation on recovering residual methane and nitrogen from digested dairy cow manure

Kaparaju, P. L. N. and Rintala, J. A. *Bioresource Technology*, 2008, 99, (1), 120–127.
The feasibility of optimizing methane and nitrogen recovery of samples obtained from farm biogas digester (35 °C) and post-storage tank (where digested material is stored for 9–12 months) was studied by separating the materials into different fractions using 2, 1, 0.5 and 0.25 mm sieves. Mass-balances revealed that digested material mainly consists of <0.25 mm (60–69%) and >2 mm (18–27%) fractions, while fractions between 2 and 0.25 mm made the rest. Incubation of solid fractions >0.25 mm of digester material at 35 °C resulted in specific methane yields of 0.060–0.085 m^3 kg^{-1} volatile solids (VS) during initial 30–50 d and 0.16–0.18 m^3 kg^{-1} VS at the end of 340 d incubation. Similarly, fractions >0.25 mm of post-storage tank material produced 0.055–0.092 m^3 kg^{-1} VS and 0.13–0.16 m^3 kg^{-1} VS of methane after 30–50 d and after 250 d, respectively. Methane yields for fractions <0.25 mm of post-storage tank was 0.03 m^3 kg^{-1} VS after 30–50 d and 0.05 m^3 kg^{-1} VS after 250 d compared to 0.20 m^3 kg^{-1} VS and 0.41 m^3 kg^{-1} VS, respectively for the same fraction of digester material. Separation of digested cow manure into solids and liquid fractions to recover methane may be feasible only for post-storage tank material and not for digester material. Nitrogen management would not be feasible with neither material as total nitrogen and ammonium-nitrogen concentrations were equally distributed among the segregated fractions.

08/01426 Energy production from agricultural residues: high methane yields in pilot-scale two-stage anaerobic digestion

Parawira, W. *et al. Biomass and Bioenergy*, 2008, 32, (1), 44–50.
There is a large, unutilized energy potential in agricultural waste fractions. In this pilot-scale study, the efficiency of a simple two-stage anaerobic digestion process was investigated for stabilization and biomethanation of solid potato waste and sugar beet leaves, both separately and in co-digestion. A good phase separation between hydrolysis/acidification and methanogenesis was achieved, as indicated by the high carbon dioxide production, high volatile fatty acid concentration and low pH in the acidogenic reactors. Digestion of the individual substrates gave gross energy yields of 2.1–3.4 kWh/kg VS in the form of methane. Co-digestion, however, gave up to 60% higher methane yield, indicating that co-digestion resulted in improved methane production due to the positive synergism established in the digestion liquor. The integrity of the methane filters (MFs) was maintained throughout the period of operation, producing biogas with 60–78% methane content. A stable effluent pH showed that the methanogenic reactors had good ability to withstand the variations in load and volatile fatty acid concentrations that occurred in the two-

stage process. The results of this pilot-scale study show that the two-stage anaerobic digestion system is suitable for effective conversion of semi-solid agricultural residues as potato waste and sugar beet leaves.

08/01427 Energy-efficient houses built according to the energy performance requirements introduced in Denmark in 2006

Tommerup, H. *et al. Energy and Buildings*, 2007, 39, (10), 1123–1130.
In order to meet new tighter building energy requirements introduced in Denmark in 2006 and prepare the way for future buildings with even lower energy consumption, single-family houses were built with the purpose to demonstrate that it is possible to build typical single-family houses with an energy consumption that meets the demands without problems concerning building technology or economy. The paper gives a brief presentation of the houses and the applied energy-saving measures. The paper also presents results from measurements of the overall energy use, indoor climate and air tightness. Furthermore, results from detailed calculations of the utilization of electricity-related heat gains are presented. Looking at the energy consumption in relation to the new energy requirements, the paper concludes that the single houses can relatively easily keep the future energy demands. The energy consumption of the houses is on a level corresponding to a classification as 'low-energy house class 2' or an energy consumption of 75% of the required maximum energy consumption. With minor modifications, some houses could be classified as 'low-energy building class 1' corresponding to an energy consumption of only 50% of the required and almost the level of typical passive houses.

08/01428 Hydrogen and electrical energy from organic waste treatment

Duerr, M. *et al. International Journal of Hydrogen Energy*, 2007, 32, (6), 705–709.
This paper presents the design details of a biogas plant and fuel cell installation that will provide a practical solution on an island (and be applicable in other remote and rural areas) where connection to the grid can be expensive, and where biofuels can be produced on site at no significant extra cost. In situ use of biomass and organic waste streams has the potential to provide the key to energy recovery and sustainability from biodegradable waste. The scheme described in this paper meets the new EU regulations covering (i) the landfill directive, (ii) the animal by-products regulations, and (iii) the biowaste directive. Traditionally biogas fuels have been used in combustion engines for electric power generation. However, there are now clear indications that given the current developments in reformer technologies, hydrogen gas can be produced from methane-derived anaerobic digestion of organic waste material – much of which is currently land filled. Hence, when utilized in fuel cells this offers the prospect of achieving higher generating efficiencies, and additionally, important environmental benefits will be achieved through mitigating greenhouse gas emissions. The solid waste from the process provides a valuable organic fertilizer which can be returned to the land thereby displacing chemical fertilizers currently in wide spread use.

08/01429 Isopropanol–acetone–hydrogen chemical heat pump: a demonstration unit

KlinSoda, I. and Piumsomboon, P. *Energy Conversion and Management*, 2007, 48, (4), 1200–1207.
The chemical heat pump is an alternative for improving the effectiveness of energy use. Waste heat at low temperatures will be recovered via a reversible chemical reaction. It will be absorbed by an endothermic reaction and transferred to new chemicals.The new chemicals are then reacted and liberate heat at high temperatures by an exothermic reaction. This paper presents a study on the development of a demonstration unit of a isopropanol–acetone–hydrogen chemical heat pump system. All major components in the system were individually investigated, which are endothermic and exothermic reactors and a distillation column. These components were then assembled and the system run. Finally, data were collected and the performance evaluated.

08/01430 Multiple regression analysis for the estimation of energy content of municipal solid waste

Agrawal, G. D. *et al. International Journal of Environment and Waste Management*, 2007, 1, (4), 376–390.
A regression equation is proposed to predict the higher heating value (HHV) of municipal solid waste (MSW) from the waste data of 86 cities of 35 countries. A mathematical model is developed, by using statistical package for social sciences (SPSS-10.0), to correlate the energy content of waste with the variables derived from its physical composition. Performance of the proposed multiple regression model is superior to available models. For validation, the proposed model is applied to the waste data of Jaipur City (India), nine cities of EEC countries and also to the MSW of USA. Energy content values obtained by proposed regression model and Modified Dulong's Equation (MDE) are closer to the measured mean energy content values for EEC countries compared to the values obtained by Khan's method. Objective of the paper is to propose a simple model, which can replace the lengthy MDE and which has universal applicability for the predication of HHVs.

08/01431 New ways for the integrated appraisal of national energy scenarios: the case of renewable energy use in Austria

Madlener, R. *et al. Energy Policy*, 2007, 35, (12), 6060–6074.
Increasing the contribution of renewable energy sources in heat and electricity production is a nationally and internationally acknowledged aim for sustainable development. In this context, the participatory development and appraisal of energy scenarios can be useful for enabling stakeholders to explore future energy options and for supporting the national policy discourse. The five renewable energy scenarios considered refer to Austria in the year 2020. The innovative methodology applied, which was developed as part of the ARTEMIS project, examines possible energy futures paths by combining (1) scenario development; (2) multi-criteria evaluation; and (3) a participatory process with stakeholders and energy experts on the national level. Economic, social, environmental and technological impacts as well as revealed social preferences are used for the ranking of the scenarios. Due to the paramount importance of bioenergy in Austria, special emphasis in the scenario development is put on the contribution of biomass. Two main bioenergy issues and their consideration in the ARTEMIS project are explicitly addressed in this paper: the cascadic utilization of biomass resources and the demand for land area and land area conflicts. Overall, it is demonstrated how the methodology can be applied in practice and what insights policy-makers can gain from it. The methodology's limitations are also explored, especially regarding the effort required for participatory scenario building and the availability of stakeholders.

08/01432 Open porous foam oxide thermoelectric elements for hot gases and liquid environments

Reddy, E. S. *et al. Energy Conversion and Management*, 2007, 48, (4), 1251–1254.
The development of open porous foams from a variety of substances such as polymers, metals and ceramics has led to many interesting applications of the porous structures. The large open porosity and high surface area of foams from oxide thermoelectric materials could also bring about new thermoelectric module designs. Currently, thermoelectric modules with bulk elements are mostly designed to extract waste heat from solid bodies for power generation. However, the majority of waste heat is generated in gaseous or liquid media. Foam structures could be an efficient solution to extract the waste heat from the hot gases and liquids as compared to their bulk counterparts. The authors detail the manufacturing of foams from oxide thermoelectric materials. Open porous foams of different porosities of n type thermoelectric $Ca_{0.95}Sm_{0.05}MnO_3$ material are fabricated as replicas of polyurethane foams. The foams are demonstrated as a thermoelectric generator in a simple module configuration with a butane flame torch as a heat source.

08/01433 Renewable energy options for a Sahel country: Mali

Maiga, A. S. *et al. Renewable and Sustainable Energy Review*, 2008, 12, (2), 564–574.
This paper presents a critical appraisal of renewable energy options for Malian modern energy technologies. A critical review of different renewable energies is presented, some comparisons between the country and other Saharan countries are listed. The study shows that Mali energy is very poor compared with other Saharan countries and the level of firewood energy is very high and the one of modern energy is very low. The study also shows that only 10% of Malians have access to electricity, the rest depend on wood, charcoal, kerosene, and petrol for their energy needs. In term of renewable energy used, Mali's balance is better than some Saharan countries. That way can be appreciated just for the new promotion and sustainability of renewable energy policy targets of the country. As a poor Country Mali can more exploit it renewable energies to combat the poverty and especially in rural zone with very low rate of electricity about 1%. The utilization of the renewable energies can also be a good opportunity to fight the desertification and dryness in Mali which is about 60% of Malian territory.

08/01434 Specific energy output from urban residues degraded with leachate and an off-specification industrial carbonated beverage as moisture sources

Jjemba, P. K. *et al. Biomass and Bioenergy*, 2008, 32, (1), 51–59.
Landfill leachate was stored at −80 °C or freeze-dried and thereafter evaluated for fermenting cellulose. The −80 °C frozen leachate degraded cellulose under anaerobic conditions, generating 80% CH_4 by 127 d. In bench-scale bioreactor studies, the fermentation of synthetic urban residues that received various amounts and types of

moisture was compared. *Archaea*, probed using fluorescent *in situ* hybridization, were significantly ($p < 0.05$) higher in leachate-moistened residues. CH_4 production was completely inhibited when a non-diluted carbonated off-specification beverage (COSB) was the source of moisture, but this treatment provided maximal H_2 production. The soluble COD was determined at two sampling intervals increased significantly ($p < 0.05$) in instances where degradation had been enhanced by the presence of a landfill leachate and a diluted COSB. The specific energy output from the fermenting residues was up to 24-fold in leachate-moistened residues compared with water-moistened residues. Thus, adding moisture to landfilled residues can add to their value but the quality, quantity, and timing of such moisture additions have a direct impact on the specific energy output from the residues.

08/01435 Technological improvements in automotive battery recycling

Kreusch, M. A. *et al. Resources, Conservation and Recycling*, 2007, 52, (2), 368–380.

Recycling of automotive batteries for the recovery of secondary lead is extremely important in Brazil, for the country does not possess large reserves of this metal. Lead is one of the most widely used metals in the world, but it is highly toxic, posing risks for humans and for the environment if not utilized or treated adequately. Industrial waste containing lead in Brazil are classified by the Brazilian Residue Code (NBR – 10004:2004) as hazardous. The lead recycling process employed by the recycling industry in Brazil is the pyrometallurgical process in a rotary furnace. This process consists of four stages: (1) grinding of the battery to separate plastic, electrolyte and lead plates; (2) lead reduction in a rotary furnace; (3) separation of metallic lead from slag; and (4) refining of recycled lead. The purpose of this work is to propose process improvements aimed primarily at increasing production output by reducing the loss of lead in slag and particulates, thereby providing a healthier work environment in line with Brazilian environmental and labor laws.

08/01436 The impact of energy consumption on economic growth: evidence from linear and nonlinear models in Taiwan

Lee, C.-C. and Chang, C.-P. *Energy*, 2007, 32, (12), 2282–2294.

This paper considers the possibility of both a linear effect and nonlinear effect of energy consumption on economic growth, using data for the period 1955–2003 in Taiwan. Evidence is found of a level-dependent effect between the two variables. Allowing for a nonlinear effect of energy consumption growth sheds new light on the explanation of the characteristics of the energy-growth link. Also provided is evidence that the relationship between energy consumption and economic growth in Taiwan is characterized by an inverse U-shape. Some previous studies support the view that energy consumption may promote economic growth. However, the conclusion drawn from the empirical findings suggests that such a relationship exists only where there is a low level of energy consumption in Taiwan. It is shown that a threshold regression provides a better empirical model than the standard linear model and that policy-makers should seek to capture economic structures associated with different stages of economic growth. It is also worth noting that the energy consumption threshold was reached in the case of Taiwan in the world energy crises periods of 1979 and 1982.

08/01437 The link between political decision-making and energy options: assessing future role of renewable energy and energy efficiency in Finland

Lund, P. D. *et al. Energy*, 2007, 32, (12), 2271–2281.

European Union and Finland are confronted with much the same kind of challenges in energy policy. Because of much higher importance on energy, these issues escalated earlier in Finland including vital political decision-making. Several alternative energy paths to the future can be identified with fairly similar projected costs. The more in-depth analysis in the Finnish case suggests that, e.g. an integrated approach consisting of renewable energy sources and energy efficiency measures would be one competitive alternative to satisfy both increasing energy demand and CO_2 emission reductions already by 2020. The study shows that meeting environmental, energy security and economical targets may not as such be adequate for the future success of an energy option. There is a more profound link between the energy options and the political decision-making, implying a much broader range of criteria than just the 3 Es reflecting thus politicians' priorities and concerns. For example, in the Finnish case renewable energy sources and energy efficiency did not match optimally the parliamentary majority's preferences when deciding on future electricity direction in 2002. The methodology suggested here can be used to improve the strategic positioning of alternative energy paths.